TECHNICAL BULLETIN

FROM

Technical Service Bureau, Inc.

CHEMISTS · ENGINEERS · INSPECTORS

407 S. DEARBORN STREET CHICAGO, ILLINOIS

MIRROR SILVERING

Bulletin No. D-123

-INCLUDES-

Simplified directions enabling anyone to apply silver on glass safely, whether resilvering old mirrors or making new ones. This bulletin gives all details you need to become expert in this work; how old silvering is stripped from the glass with acid, how glass is cleaned before applying the silvering solution, how silvering solutions are prepared and applied on a simple, homemade silvering tray. Also includes information on colored mirrors, front-surface mirrors, and transparent mirrors such as a mirror that becomes a photo and vice versa -- All explained in easy -to- understand language which takes the mystery out of this profitable work.

-$1.00-

All Technical information, processes and methods recommended in this bulletin have been checked or tested and approved.

Technical Service Bureau, Inc.
By CLYDE A. CROWLEY
Technical Director

TABLE OF CONTENTS

ILLUSTRATIONS

MIRROR SILVERING

Anyone can silver new mirrors or resilver old mirrors by the simplified methods outlined in this bulletin. The methods are simple, and sure. Complete directions are given, including the proper method of stripping old mirrors without damaging the glass, means of insuring a clean surface for silvering, how to mix the silvering solution and how to use them. The most important secret, and at the same time the most difficult part of this intriguing process, lies in getting the glass perfectly clean before attempting to silver it. The last traces of grease must be removed to insure complete coverage by the silver. The first part of this bulletin, therefore, will concern itself with the methods of cleaning the glass, and the second will describe the process of silvering. First, however, a caution on the use of chemicals.

SAFE USE OF CHEMICALS - The safe use of chemicals is a matter of knowing the dangers involved in dealing with them, and then taking the proper precautions to prevent accidents. Chemists, students, laboratory technicians, factory hands, constantly handle strong acids, deadly poisons such as cyanides and arsenic compounds and other chemicals without accidents simply because they know and follow simple precautions.

In the first place, all containers and bottles should be clearly and correctly labeled. All corrosive or poisonous chemicals should be labeled as such. The labels should be brushed with melted paraffin to prevent acids or acid fumes from destroying them. This precaution is particularly necessary in the case of strong acids. Don't try to save a few cents by using an unmarked chemical for what you think it is, and above all, don't taste it to identify it. The only safe way to handle it is to throw it away. All chemicals should be placed out of reach of children and others who don't know their proper use.

Silver nitrate is a corrosive substance and should be kept off the skin and especially away from the eyes. It will leave ugly brown stains and if left on may result in bad burns. Nitric acid is one of the strongest known acids and should be handled with the respect due it. It is highly corrosive to nearly all metals, and to the skin, clothes, wood, and many other materials. Ammonium hydroxide is a relatively strong base or alkali and its vapor is extremely irritating to the nose and throat. Bottles containing ammonia should be kept stoppered. Solutions containing both ammonia and silver nitrate will form highly explosive compounds if left standing for a long time and, therefore, it is important to observe the cautions given later relative to mixing the silvering solution and discarding immediately that which is not used.

It is not advisable to pour solutions containing silver down the drain pipe, as chemical action may corrode or destroy the pipe. This is particularly true if large quantities of these solutions are used. Waste silver solutions should be treated with common salt (sodium chloride), which will precipitate the silver. The solid matter formed should be discarded and the solution may be poured down the drain pipe.

THE TRAY - The mirror to be resilvered should be placed face down on a smooth, level surface to prevent breakage and for the sake of convenience. This method eliminates the necessity of handling the mirror in the course of operations and makes the application of cleaning solutions and the silvering solution most convenient. The most convenient arrangement is shown in Fig. I. A tray large enough to hold the glass is made by bending up the edges of a sheet of galvanized iron as shown. Note that one corner is bent down to form a lip over which excess solutions can drain into the catch bucket placed on the floor. To prevent corrosion of the metal by acids or by plating solutions, the tray should be given a heavy coat of asphaltum paint both inside and out.

Asphaltum varnish can be prepared as follows:- dissolve asphaltum 2 parts, in turpentine 10 parts. Separately mix white lead, 1 part with turpentine 1 part. Now add the asphaltum mixture to the white lead mixture and stir in one part of varnish,

preferably damar varnish. Ordinary asphaltum paint diluted with an equal quantity of benzol can also be used.

The tray will be used both for cleaning and silvering. Four leveling wedges will be needed to support the glass as can be seen from Fig. I. These should be cut from hardwood to the dimensions shown in the detail, and need not be painted. By adjusting their positions at the corners of the mirror, it is easy to make the mirror level so that the solutions will not run off.

STRIPPING AN OLD MIRROR - The first operation in handling an old mirror is stripping all the old reflecting surface. First, the protective varnish coating must be removed, which is done by pouring varnish remover on the surface. The varnish remover is allowed to remain on the mirror until the old varnish has softened which permits it to be wiped off with a soft clean rag or clean cotton. Scraping or hard rubbing is to be avoided as there is constant danger of scratching the glass, and any such marks will show up when the mirror is completed. It will usually require ten or fifteen minutes to soften the old varnish sufficiently to remove most of it with a soft cloth. If necessary, a second application of varnish remover can be used to remove any traces of varnish left after the first treatment.

The old silver can be removed by pouring on the surface a solution made by adding nitric acid 1 fl. oz., to water 6 fl. oz. The acid may be swabbed over the surface with a wad of cotton on the end of a wooden stick to insure thorough wetting of the surface. This acid solution will remove the old silver completely if all the old varnish has been removed. If some of the silver remains, it will be necessary to remove the thin film of varnish which protects it by treating the surface again with varnish remover; and again applying the nitric acid solution to dissolve the silver.

CLEANING THE GLASS - The glass from which the silvering has been removed or the glass for the new mirror, as the case may be, must now be subjected to a thorough cleaning routine which will insure a chemically clean surface to which the silver will adhere readily. Failure to clean the glass thoroughly is almost always the cause of unsuccessful silvering. Consequently, the importance of the cleaning method which will now be described cannot be over-emphasized. To remove all traces of grease from the glass, it is washed thoroughly with a hot solution of washing soda 1 lb., dissolved in water 1 gallon. After this washing the glass must not be touched or handled in any way. The slight oily film on the hands will leave a grease spot which will prevent perfect adhesion of the silver. Following the first wash, the glass is rinsed well with warm water. The second and final washing is accomplished with a solution made by dissolving C.P. nitric acid 1 fl. oz. in distilled water 6 oz. The abbreviation C.P. stands for a high grade of chemicals, which are designated as "chemically pure". Wash the acid away by flooding the surface with distilled water, and level the glass by tapping the wedges lightly until a pool of water will not tend to flow towards the edges, but spreads out evenly over the surface. At this stage in the preparations, the water should lie in an unbroken film over the whole surface. If it fails to wet any part of the glass, or tends to roll back and leave any part dry, it is a sign that the part is not clean, and the cleaning routine must be repeated. Following the past rinse, a solution made by dissolving stannous chloride 1 dram in distilled water 1 gallon, is flowed onto the surface and allowed to stand until the silvering solution is ready to use.

SILVERING SOLUTIONS - The silvering formula consists of two solutions which are designated as the silver solution and the reducing solution. The latter may be made up in any quantity and stored until needed, but the former cannot be mixed more than a few hours before use and must not be allowed to stand overnight or longer. Dangerous, explosive compounds may be formed when this solution stands for long and so this caution should be strictly observed. The two solutions are not to be mixed before use as silvering action starts immediately after mixing and too early mixing means wasted silver and weakened solutions.

The silver solution is made by dissolving C.P. silver nitrate 1 oz., in distilled water 10 fl. oz. The silvering solutions should be made with C.P. chemicals and distilled water should be used

throughout. When silver nitrate has completely dissolved, add C.P. ammonium hydroxide (household ammonia cannot be used), slowly, drop by drop, shaking or agitating between additions, until the precipitate which forms at first just redissolves. The ammonium hydroxide can be added conveniently from a medicine dropper or a pipette if one is available. No more ammonia should be added than the final drop which causes the last of the precipitate to redissolve. When this has been completed, add a solution made by dissolving C.P. potassium hydroxide (sticks) 1 oz., in distilled water 13-1/2 fl.oz. Addition of this solution to the silver solution will cause a heavy precipitate to form. Again add ammonia drop by drop, shaking or mixing between additions, until this precipitate has just redissolved. Finally, add just enough of a solution of silver nitrate 1-1/4 oz., in distilled water 12-1/4 fl. oz., to turn the mixture a light straw color. The silver solution is now completed.

The reducing solution is made by dissolving granulated sugar 1 oz., in distilled water 10 fl. oz. When the sugar has dissolved, add pure grain alcohol (not denatured) 1 fl. oz., and C.P. nitric acid 24 drops. Heat this solution to the boiling point and allow it to cool before use. As this solution will keep, it may be made up in any required quantity and stored for future use.

SILVERING - When the above preparations have been completed, rinse the stannous-chloride solution from the glass with distilled water. Mix two parts by volume of the silver solution with one part by volume of the reducing solution and immediately flow this mixed solution onto the glass. Let it stand until the silver has completely deposited, which will require about ten minutes.

When the silvering has been completed, rinse the silvered glass with cold water and swab the surface gently with a piece of absorbent cotton. Then permit the mirror to dry thoroughly. Do not use forced drying as this is likely to damage the freshly silvered surface. When the surface has dried thoroughly, it should be given a protective coating to prevent damage or oxidation of the silver. A coating of black lacquer or a good grade of varnish applied with a soft brush will be satisfactory. The finished mirror should be mounted as shown in Fig. 2, to prevent damage from abrasion or dust.

AMOUNT OF SOLUTION REQUIRED - The amount of silver solution made as described above is enough to silver 200 to 250 sq. inches of glass. If larger mirrors are to be covered, larger amounts of the silver solution should be prepared, without changing either the proportions or the manner of preparation. The solution should be made up in sufficient quantity.

FRONT SURFACE SILVERING - Mirrors used in telescopes, high grade optical instruments, and other applications where the faint reflection from the glass surface is objectionable are silvered on the front instead of on the back. This is generally called front-surface silvering. The same cleaning and silvering methods can be used in this process as are followed in ordinary silvering except that the work must be placed in the tray face up instead of face down. The silver surface, of course, cannot be lacquered or varnished and so front-surface silvered mirrors must be kept away from the atmosphere and in dust proof boxes whenever not in actual use.

COLORED MIRRORS - Striking mirrors for decorative purposes may be made by depositing silver on colored instead of clear glass. Such mirrors lend a distinctive touch to the home, restaurant, window display, or other places where they are used. A dark colored mirror makes an attractive background on which to set a centerpiece for table, mantle, or buffet. Interesting reflections from colored mirrors will liven up window displays and attract attention of passers-by.

TRANSPARENT MIRRORS - Transparent mirrors which appear as transparent or reflecting surfaces according to the lighting are made by depositing a very thin coating of silver in the same way as described above. One application of such a mirror is shown in Fig. 3. The mirror becomes a photo when the light behind it is turned on. The glass is prepared in the usual way and placed on the tray with a piece of newspaper below it. The silvering solution is applied and the process carefully watched until the printing on the newspaper is just barely

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visible. Then the glass is tilted and the excess solution is poured off. The mirror is rinsed, dried, and the silver surface is coated with clear lacquer. A reflector is cut from sheet metal, the two semi-circular side pieces and a rectangular piece which is curved to form the back, being soldered together. Then a socket for the 10-watt lamp is inserted through a hole cut in the back. The photo must be transparent and should be printed on a film or on a glass plate. To assemble the unit, place the mirror in the frame, the picture behind it, and a piece of plain glass behind the picture.

SEMI-TRANSPARENT MIRRORS - Mirrors of this type may be used wherever it is desired that people on one side may see through a glass but that those on the other side may not. If the light on one side is appreciably stronger than that on the other, the glass will be transparent from the darker side and reflecting from the brighter side.

SUPPLY DIRECTORY

Chemicals of all kinds, including those needed for silvering mirrors may be obtained from:

a) A. Daigger & Company
159 W. Kinzie Street
Chicago, Illinois

b) W. M. Welch Manufacturing Company
1515 North Sedgwick Street
Chicago, Illinois

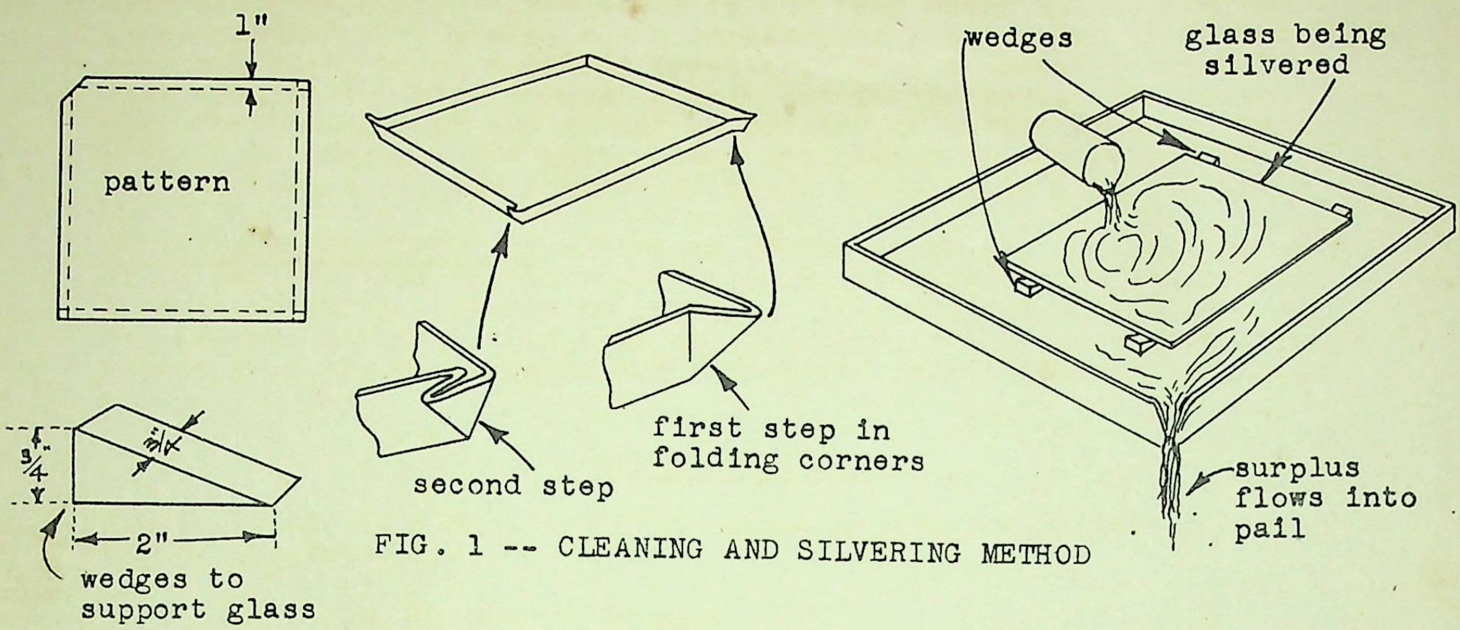


FIG. 1 -- CLEANING AND SILVERING METHOD

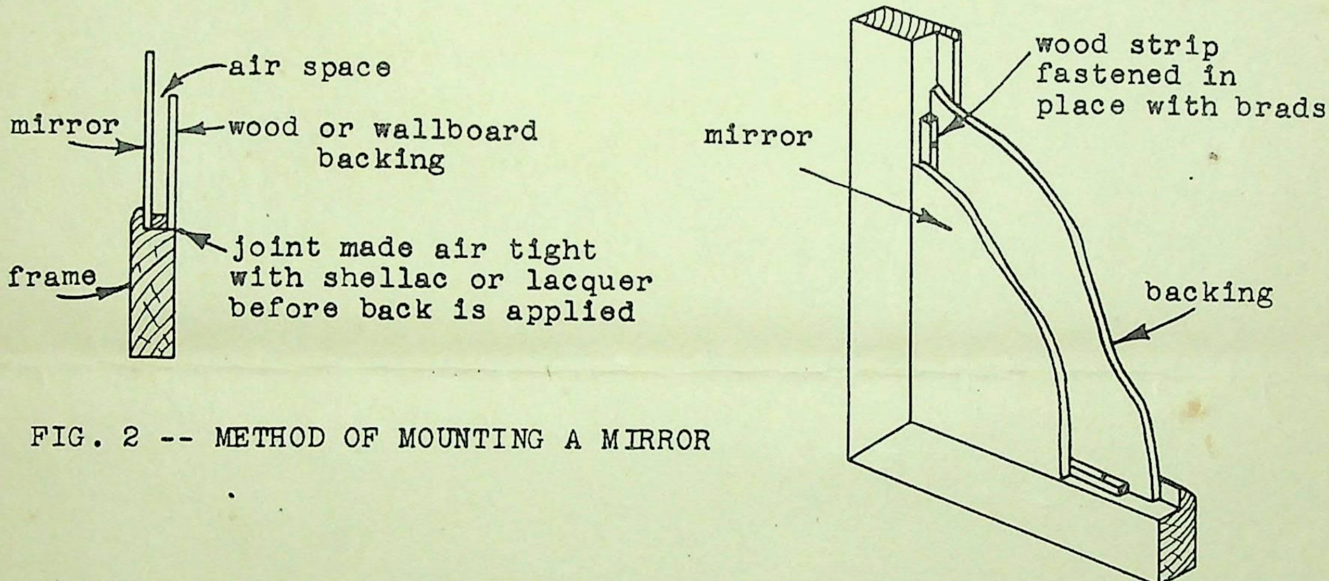


FIG. 2 -- METHOD OF MOUNTING A MIRROR

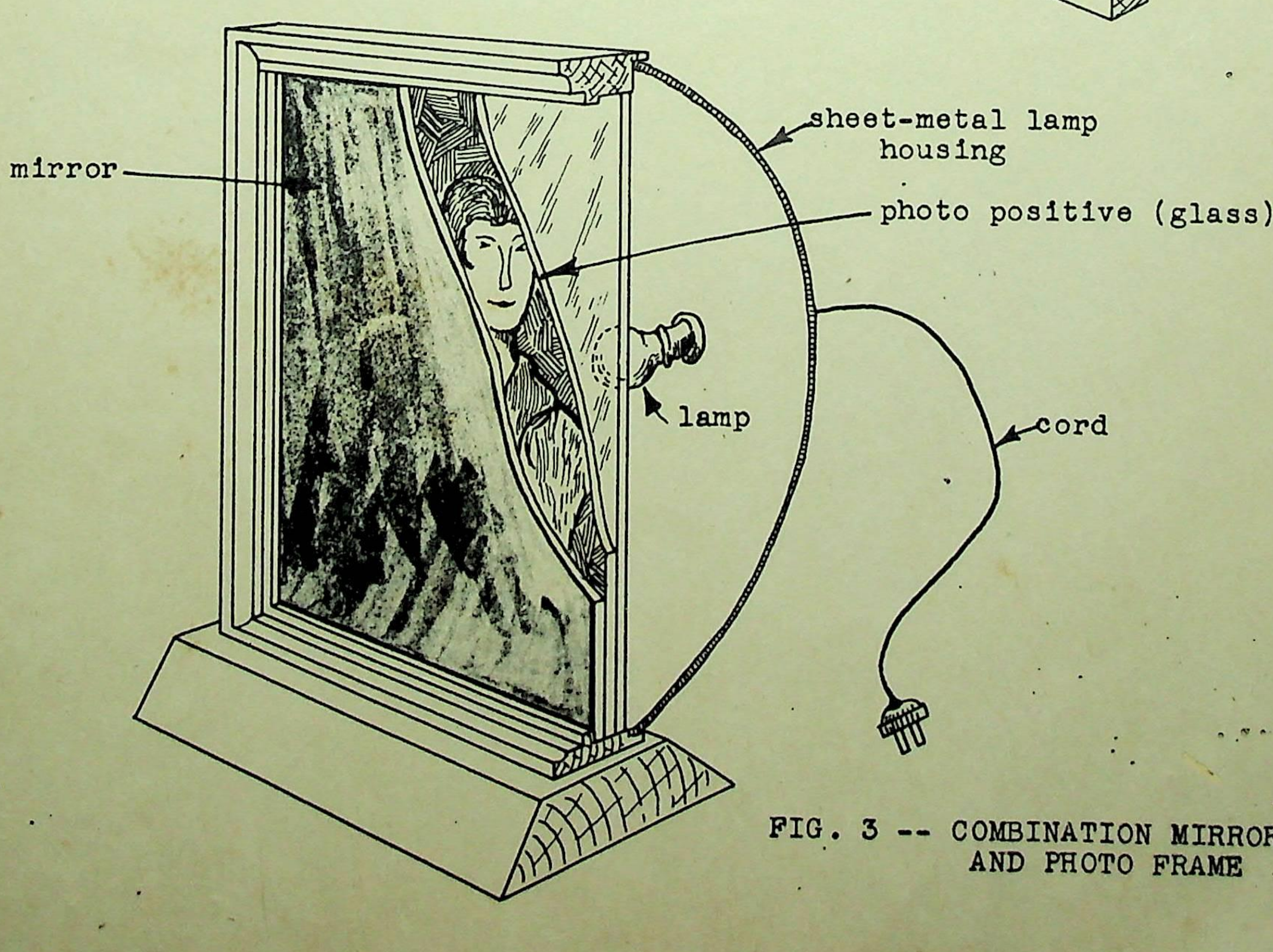


FIG. 3 -- COMBINATION MIRROR AND PHOTO FRAME

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407 S. DEARBORN STREET CHICAGO, ILLINOIS

BUFFING AND POLISHING METALS

Bulletin D-125

-INCLUDES-

An explanation of methods and procedures which result in high quality work and increased profits. Complete simplified information in this bulletin tells what grit or abrasive to use for polishing and buffing metals including steel, stainless steel, monel metal, aluminum, brass, copper, zinc and nickel. Describes how to apply glue and grit to wheels. Also gives proper speeds to run wheels and the types and sizes of motors for best results, -- plus numerous other details that anyone should know to become an expert in this work.

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TABLE OF CONTENTS

BUFFING AND POLISHING OF METALS

The finishing of metals by polishing is a process of great value in the shop, and yet, too often, it is not carried out properly. Metal articles which are well polished have an improved appearance which may be of positive value in articles to be sold. Moreover, polished articles have greatly increased resistance to corrosion, especially to atmospheric corrosion. Polishing is also a necessary operation preliminary to plating, as the luster of the plate depends to a very large measure on the finish of the surface preliminary to plating. A polished surface is absolutely essential if a s mooth plate is desired. Polishing is frequently of value before other finishing operations such as applying a baked-on enamel finish. In short, it is an absolutely indispensable operation in home workshop, small shop, or factory. The directions given in this bulletin will enable anyone who is willing to spend a little time practicing, to get the greatest efficiency and the best results in the least time.

Polishing of a metal surface divides itself into three distinct processes; grinding, polishing proper and buffing. Grinding is the use of a rigid wheel composed of abrasive grains firmly bonded together to cut down a surface. It serves to remove large scratches and irregularities from the surface. It is frequently necessary as a first process in giving a metal object a polished surface, and where necessary it should be carried out with an emery wheel or with a wheel made of an artificial abrasive, such as aluminum oxide or silicon carbide. The synthetic abrasives are generally better because they are more uniform. The grinding process will leave a relatively smooth surface which is covered with a multitude of fine scratches, and which, consequently, presents a dull appearance. It is the purpose of the buffing and polishing operations to remove these fine scratches and leave a smooth and lustrous surface.

Polishing is the process of brightening metal surfaces by means of a somewhat flexible wheel coated with abrasive material. Polishing removes the fine scratches left after grinding, by cutting away small amounts of metal from the surface. Very often polishing will leave the metal surface in a state which requires no further treatment. However, the polished surface itself is covered with exceedingly fine marks, left by the cutting action of the polishing wheel, and while the marks are very small, still they leave a somewhat dull surface. Where a very fine or highly lustrous finish is desired, the polishing operations must be followed by buffing with a soft wheel and very fine abrasives. This removes even the fine marks left after polishing and leaves a surface which is highly lustrous and smooth.

Buffing is distinguished from polishing in that in buffing the abrasive is fed on to the wheel during operation, while in polishing the abrasive is glued on to the wheel before use. The distinction however, is really deeper than this. In the first place, the abrasives used in polishing are coarser than those used in buffing. Polishing abrasives generally run from 120 to No. 220, while buffing abrasives generally are finer than No. 220. These numbers represent the fineness of the grit, higher numbers meaning finer grains. They indicate the finest screen (the number being the number of openings per inch in the screen) through which the grit will pass. Moreover, the abrasives used in buffing are generally softer than those used for polishing; and the wheels used are softer and far less rigid. Buffing is frequently used to produce high luster on a metal surface; polishing is used as a final finish on an article where too high a luster is not desired, and as a preliminary operation to buffing, plating, or other finishing operations. Very often the terms "coloring", for the final buffing process and "cutting down" for the preliminary polishing operations are used.

POLISHING WHEELS - Polishing wheels are made from a large number of materials. Wood faced with leather, sheepskin, bull-neck and walrus leather, canvas, felt, muslin and flannel are some of the materials used most frequently. Leather-faced wooden wheels are, of course, quite rigid, and while they are very good for polishing flat surfaces, such as sheet metal they are not suitable for rounded articles, be-

cause they touch such a small part of the surface at one time. The other materials mentioned are preferred for surfaces other than flat sheets. Bull-neck and walrus leather wheels are somewhat flexible and give very good results. Cloth and sheepskin wheels are softer and semi-flexible, and are well suited for use as general service polishing wheels. Leather and cloth wheels consist of a number of layers of the material cemented together. In the case of cloth wheels, several layers of cloth are tightly sewed together and a number of these discs are cemented together to form the polishing wheel. Buffing wheels are generally made of layers of cloth or sheepskin more or less loosely sewed together.

ABRASIVES FOR POLISHING AND BUFFING - The abrasives used in polishing and buffing include a great variety of natural and synthetic materials. On polishing wheels, the most generally used abrasives are the artificial grits such as alumina and silicon carbide, and natural emery. Emery is very widely used, and gives good results; but the artificial abrasives have the advantage of greater uniformity and, for some purposes at least are to be preferred to emery. Natural abrasives are used almost entirely for buffing although synthetic aluminum oxide (alumina) is sometimes used, for example, on stainless steel. Buffing compounds are generally sold in the form of a stick or cake consisting of the abrasive and grease or tallow. This compound is applied to the buff by friction; the stick is held against the moving wheel under moderate pressure. The abrasives generally used for buffing are emery, tripoli, pumice, crocus, lime and rouge. These will now be taken up in that order, which is the order of decreasing hardness and sharpness.

EMERY CAKE for buffing comes in a variety of degrees of fineness running up to 200 and including even finer sizes, known as "flour sizes" and designated by the letters, F, FF, and FFF. It can be used on most metals as a first buffing compound for removing the last fine scratches left by polishing. The finest grades can be used to produce a very good finish. Emery in any form must not be used on stainless steel, as it contains iron.

TRIPOLI is a very versatile buffing compound. It has soft porous grains without hard, sharp surfaces; so that it is useful in producing a fine polished surface. At the same time, the grains are tough enough to cut down the superficial marks left after polishing. It is especially useful in buffing soft metals, such as brass and aluminum, as onethese metals it can often be used to produce a finish in one operation.

PUMICE is ground volcanic lava and is useful for producing brushed effects, for which purpose it is applied with a Tampico brush. It is also used as a soft buffing compound.

CROCUS is an oxide of iron, comparatively hard, and is used on cutlery steel and other articles which require a rather high finish.

VIENNA LIME or VENETIAN LIME is a very soft compound and is used extensively in polishing nickel plate.

ROUGE is one of the softest of buffing compounds and is used for the finest effects as on jewelry.

A number of other buffing compounds are used, among which is chromium oxide or "green rouge" which is used for the finest finishes on stainless steel and also for fine finishes on Monel metal and nickel plate. Fine alumina is also used as a buffing compound, especially on stainless steel.

PREPARATION OF WHEELS - The abrasives used in polishing are held on the wheel with glue. It is the best practice, and, in the long run, the most economical, to use the best grade of glue obtainable. Animal hide glue of good quality is generally conceded to be the best adhesive for polishing wheels. Although it is somewhat more expensive than other types of glue, it will repay the extra cost in increased life of the coated surface of the wheel. The glue should be purchased in dry form, preferably ground, although cake or flake glue can also be used. This should be mixed with water by weight and in small batches. Only as much as can be used immediately or within a few hours should be mixed at one time. The ground glue should be weighed, and the water should be measured in a graduated vessel, on the basis of one fluid ounce equals one ounce avoirdupois. Table I gives the recommended proportions of glue and water for the various

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PREPARATION OF WHEELS - The abrasives used in polishing are held on the wheel with glue. It is the best practice, and, in the long run, the most economical, to use the best grade of glue obtainable. Animal hide glue of good quality is generally conceded to be the best adhesive for polishing wheels. Although it is somewhat more expensive than other types of glue, it will repay the extra cost in increased life of the coated surface of the wheel. The glue should be purchased in dry form, preferably ground, although cake or flake glue can also be used. This should be mixed with water by weight and in small batches. Only as much as can be used immediately or within a few hours should be mixed at one time. The ground glue should be weighed, and the water should be measured in a graduated vessel, on the basis of one fluid ounce equals the ounce avoirdupois. Table I gives the recommended proportions of glue and water for the various

sizes of abrasives. The ground glue should be soaked in cold water for not less than one hour. Flake glue should be soaked for at least six hours and cake glue should be soaked for not less than 12 hours. After soaking for the required time, the glue should be carefully heated to a temperature of 140oF. Either a water-jacketed glue pot or an electrically heated glue pot should be used for heating the glue, and its temperature should be checked with a thermometer in order to avoid overheating the glue. It is important to avoid overheating the glue, as this will weaken it and lessen its adhesive properties. When the glue has reached 140 degrees, it should be applied quickly to the surface of the wheel and spread evenly with a clean brush. It is good practice to have the wheel heated to the same temperature as the glue, in order to prevent chilling and jelling of the glue. This can be accomplished by placing the wheel in an oven with the gas turned low. For convenience in handling, the wheel should be mouhted on a stake or mandrel during these operations. The glue coated wheel is then rolled through a trough containing the abrasive until it is thoroughly and evenly coated. The stake should be grasped in both hands during this operation, as shown in Fig. I. A trough for this purpose can be readily made from sheet metal, light wood, or even cardboard. It should be slightly wider than the widest wheel to be handled and preferably should have a curved bottom, the radius of curvature being somewhat greater than that of the largest wheel. After the abrasive has been applied, the wheel can be tested by rolling it lightly over a metal plate. If the glue comes to the surface of the wheel, more abrasive should be applied; if the abrasive comes off, then there is too much abrasive on the wheel. The excess should be lightly brushed off after the wheel has dried. The wheel should than be set aside to dry for twenty-four hours or more, in a warm dry room. It should be rested between two supports on a stake through its arbor hole.

A new wheel should always be given a thin sizing coat of glue before the abrasive coating is applied. Generally two coats of abrasive are applied to the wheel. If an old wheel, which is to be recovered is in bad shape, covered with excessive grease or oil, or badly pitted, the best method is to soak the head off and treat the wheel as a new wheel. If the wheel is worn through the sizing coat, it should be resized. In any case, before a wheel is recovered, its surface should be trued up with a silicon carbide stick before the new coating of glue is applied.

PREPARATION OF BUFFING COMPOUNDS - Buffing compounds in stick form can be purchased, but it is easy to make your own and the cost will be less. The buffing sticks are made by melting together equal parts of hard tallow and paraffin wax. The proportions may be varied depending on the hardness desired; the greater the proportion of paraffin, the harder the stick will be. For higher speeds, a somewhat harder stick is desirable. Beeswax is better than paraffin; however, its cost is considerably more. When the waxes have melted and are thoroughly mixed, add powdered abrasive with constant stirring until the mixture becomes quite thick. While it is thick but still molten, pour it into long slender paper tubes, cardboard mailing tubes, cardboard boxes or some other form. The abrasive used should be selected according to the use for which it is intended; the characteristics of the various abrasives have been pointed out above. The name and grade (grain size) of the abrasive should be stamped on each side; or, if desired, each compound can be identified by color. To do this, simply add a little dye to the melted wax before adding the abrasive. For general uses, perhaps tripoli, fine emery and crocus will be the most valuable buffing compounds, while lime, rouge, and green rouge are valuable for their own special applications to fine work.

MOTOR AND PULLEY SIZES - The motor driving a buffing or polishing wheel should be of adequate size to drive it at constant speed without overheating. Constant-speed, shunt-wound motors on direct current and squirrel-cage induction motors on alternating current are the best types of motors for operating buffing and polishing wheels. Both of these types of motors run at a practically constant speed. The desired speed can then be obtained with a pulley arrangement; cone pulley can be used if several speeds are desired. The required

pulley diameter for a given wheel speed can be found from the formula:

Diameter of Motor Pulley =

$$\frac{(\text{R.P.M. required})\ (\text{Diameter of driven pulley})}{(\text{R.P.M. of motor})}$$

Since polishing wheels generally have only one pulley, speed adjustments must be made by altering the pulley size on the motor. For example, suppose that the motor has a speed of 1750 R.P.M. and the wheel is to be driven at 500 R.P.M. The diameter of the pulley on the wheel is let us say 1-1/2". (The diameter of V-type pulleys is always measured at the bottom of the V). The correct size of the motor pulley is found by multiplying 5000 by 1-1/2, which gives 7500; and then dividing this answer by 1750, giving a result of 4.28 inches. The nearest standard pulley sizes are 4" and 4-1/2", and either size can be used to give approximately the desired speed. The larger motor pulley will give a somewhat higher wheel speed than the smaller. Table II gives suggested motor sizes for operating different size wheels. The motor and wheel should always be connected so that the top of the wheel turns towards the operator; clockwise, as viewed from the operator's left. See Fig. 2. The work can then be held against the lower part of the wheel, so that the operator can watch it as the finish develops.

WHEEL SPEED - The speeds for grinding, polishing and buffing wheels are figured in surface feet per minute, rather than revolutions per minute. The surface feet per minute of any particular wheel is obtained by multiplying the circumference in feet (which is 3.1416 times the diameter) by the R.P.M.'s. Polishing and buffing wheels operate at speeds running all the way from 2500 to 7500 surface feet per minute, and sometimes higher; but the most general operating speeds are from 3000 to 6000 S.F.M. Chart I gives data for converting surface feet per minute to revolutions per minute for various wheel sizes. To use the chart, find the diameter of the wheel on the bottom of the graph, follow the vertical line corresponding to that diameter up to the curve marked with the desired surface speed; then from that point read straight across to the left hand margin, where the R.P.M.'s can be found. If the desired surface speed is not shown e.g., if the speed of 3500 S.F.M. is not shown, the R.P.M. can be found by averaging the next smaller and next larger values. Thus, for a six inch wheel, 3000 S.F.M. (surface feet per minute) is equivalent to 1900 R.P.M., and 4000 S.F.M. is equivalent to 2550 R.P.M. Therefore, for a speed of 3500 S.F.M., the velocity in R.P.M. should be (1900 plus 2550 divided by 2 or 2225 R.P.M.). Suggested wheel speeds are only approximate and there is no necessity for adjusting them closer than within 100 or 200 S.F.M.

SUGGESTED POLISHING METHODS - The sequence of operations followed in polishing and buffing any metal article must be determined by the initial state of the object to be polished, the final finish desired, and the metal of which the article is made. Soft metals may need fewer operations than harder metals. A rough casting will require more polishing than a sheet of metal that is already smooth. If a mirror finish is desired, operations must be continued down to the softest buffing materials; if a duller surface is satisfactory, perhaps no buffing operations at all will be needed. The skill of the operator also has much to do with the polishing sequence; a skillful and experienced workman can produce a given finish with fewer operations than a less experienced man. The following suggestions, therefore are not absolute, and they should be applied to any particular job with the thought that the only purpose of polishing is to produce a certain finish; and the system that produces that finish in the shortest time is the best system. In certain cases wheel speeds have been suggested; where they have not, a speed of 5000 to 6000 S.F.M. will be satisfactory.

STEEL - For polishing steel, use first a No. 120 abrasive on a dry rag wheel, followed with a No. 150 on a greased rag wheel, and finally with No. 180 on a greased rag or sheepskin wheel. The article can

then be buffed with No. 180 emery cake or paste on a Tampico brush wheel. Rough steel castings or forgings can be given a preliminary rough polishing with a No. 60 polishing wheel. This treatment gives a final finish which is suitable for plating.

STAINLESS STEEL - Stainless steel requires a somewhat different treatment from ordinary steel. Manufacturers recommend that no abrasives containing iron be used on stainless steel; this eliminates emery, crocus and ordinary rouge. Generally synthetic aluminum oxide grits are used for the polishing and the first buffing operations. Tripoli may also be used for buffing and the highest luster developed with chromium oxide or "green rouge", as it is usually called.

A suggested sequence of operations would be polishing with No. 90 and No. 120 artificial alumina on dry rag polishing wheels, a final polish with No. 180 on a greased polishing wheel, and buffing with tripoli. For a mirror finish, the article is buffed again with very fine aluminum oxide buffing compound, and finally with green rouge. For a satin finish the final operation is brushing with pumice on a Tampico brush.

FINISHING BRASS - Brass being softer than steel will usually require fewer polishing and buffing operations. Brass castings can be polished with No. 80 and No. 120 and finally with No. 180 on a greaded wheel, and then buffed with an emery-grease compound. Stampings can be polished similarly at 5500 or 6000 S.F.M. and then buffed on a loose muslin buff at a slower speed such as 4000 S.F.M. Buffing may be with fine tripoli. For nickel plating there should be a final buffing with lime on a muslin or linen wheel, after which the buffing compounds are cleaned off and the article is plated. Castings may also be buffed with tripoli and lime if desired.

When working with brass, caution must be exercised not to apply too much pressure, otherwise the metal will get too hot. Excessive heat causes the abrasive to break away from the prepared wheel and mark the work. Marks caused by this are very difficult to remove.

In the case of brass castings, as well as castings made from other metals, they should be sandblasted or tumbled before polishing in order to remove all sand which may be adhering as a result of the casting operation. In general, sand blasting is preferable to tubling, particularly in the case of delicate parts which might be damaged by tumbling. Large or rugged parts may be tumbled by placing them in a barrel together with wet sand or other wet smooth abrasive material and rotating the barrel. It is easy to mount a small barrel, not upright but rather at an angle, on a motor driven plate for this purpose. The barrel should rotate at slow speed so that the sand and castings tumble constantly. After tumbling, the parts are freed from sand by washing in water.

BUFFING AND POLISHING ALUMINUM - Aluminum is very soft, and hence it is desirable to lubricate all the finer polishing wheels used on aluminum to prevent tearing of the metal. Certainly all wheels finer than No. 120 used on aluminum should be greased. The wheel is greased by applying a tallow stick or cake to its surface while it is running. Kerosene is used sometimes as a lubricant on wheels for aluminum. Aluminum articles should be polished at 5500 S.F.M. using Nos. 80, 120 and 180 grits on the wheels. The No. 80 wheel may be used dry. It should then be buffed with tripoli and lime on a muslin buff, and finally with rouge, if desired. The buffing operations can be carried out at a somewhat higher speed, 7000-7500 S.F.M. Scratch-brushing at low speeds (600 R.P.M. with a 6 inch brush) produces a dull gray finish. A satin finish can be produced by brushing with fine alumina on a Tampico brush at 3000 S.F.M. A similar finish can be produced on brass or steel with pumice and water at the same speed.

ZINC DIE CASTINGS - Zinc die castings can be polished with No. 120 grits then buffed with tripoli, then buffed at 6000 S.F.M. with a soft buffing compound. As an alternative final operation, zinc articles can be brushed with fine pumice and water on a Tampico brush at a low speed. Zinc plated surfaces can be buffed with tripoli and lime.

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MONEL METAL; NICKEL, COPPER AND CHROMIUM PLATE - Nickel and copper plated surfaces should be buffed with lime on a soft wheel, and then with rouge. A nickel surface which is to be chromium plated requires careful buffing, as the final finish will show up any marks left after buffing. Monel metal can be buffed with fine emery cake, then with tripoli, then with lime or chromium oxide rouge. This sequence is also good for polishing nickel to receive a chromium plate. The chromium plate itself probably will not need buffing, but if desired it can be buffed with green rouge.

BUFFING AND POLISHING COPPER - It is not often that copper parts present themselves for buffing and polishing, however when they do, special problems are imposed. At no time must copper be pressed too hard against the wheel. Plenty of grease must be used and as little pressure as possible. Hurrying is to be avoided as copper heats badly during these operations and holds its heat for a longer time than most metals. In general, it is well to start with No. 60 or 80 grit and follow with No. 120. The job can than be finished with No. 140 or No. 180 grit. Before attempting an important copper job, it will pay to practice on a scrap in order to get the feel of this metal and see for yourself just how troublesome it can be if the job is rushed.

TABLE I

COMPOSITION OF GLUE FOR POLISHING WHEELS

Abrasive grain size	Dry glue % by weight	Cold water % by wt.
30-36	50	50
46-54	45	55
60-70	40	60
80-90	35	65
100-120	33	67
150	25	75
220	20	80

TABLE II

MOTOR SIZES FOR POLISHING AND BUFFING

Diameter of wheels in inches	Horsepower required
6	1/4
10	1
12	2
14	3

SUPPLY DIRECTORY

Emery, pumice, crocus, vienna lime, alumina, rouge, etc.	A. Daigger & Company 159 W. Kinzie Street Chicago, Illinois
Abrasive sticks, buffing compounds, emery cake, etc. and Polishing lathes, polishing wheels, polishing machines and other supplies	Hanson-VanWinkle-Munning Co. 2920 Carroll Avenue Chicago, Illinois and Chas. F. L'Hommedieu & Sons Company 4521 W. Ogden Avenue Chicago, Illinois

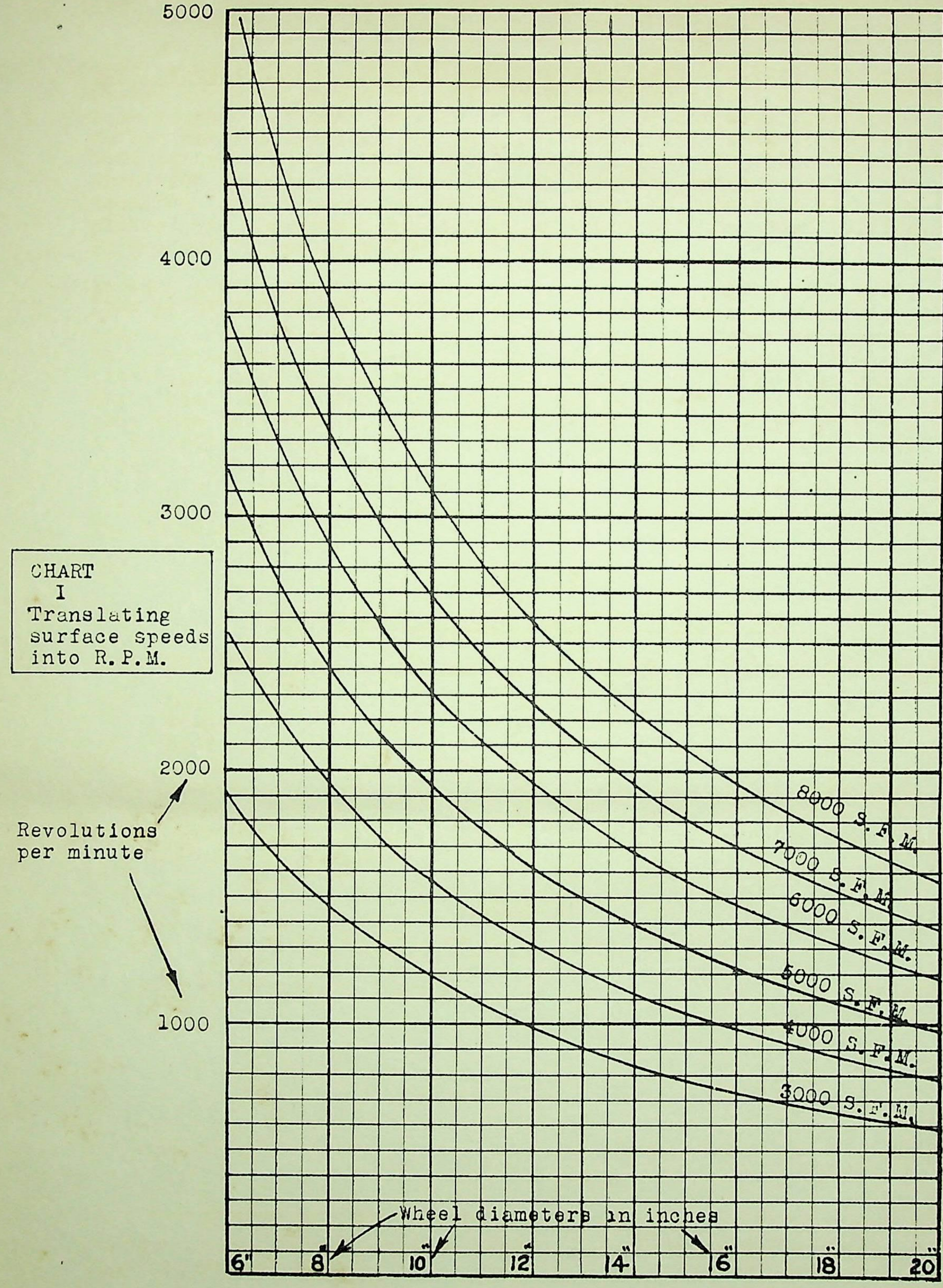
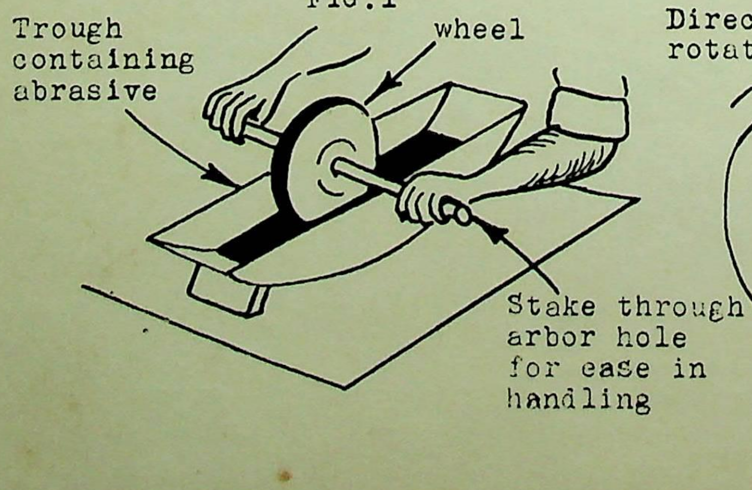

5000
4000
3000
2000
1000
CHART
I
Translating
surface speeds
into R.P.M.
Revolutions
per minute
8000 S.F.M.
7000 S.F.M.
6000 S.F.M.
5000 S.F.M.
4000 S.F.M.
3000 S.F.M.
Wheel diameters in inches
6"
8"
10"
12"
14"
6"
18"
20"

FIG.1


Trough
containing
abrasive
wheel
Stake through
arbor hole
for ease in
handling

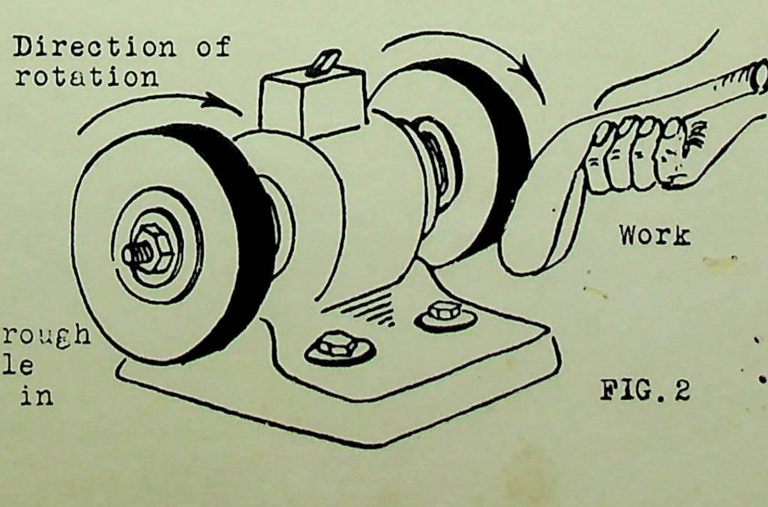

Direction of
rotation
Work

FIG. 2

TECHNICAL BULLETIN

FROM

Technical Service Bureau, Inc.

CHEMISTS · ENGINEERS · INSPECTORS

407 S. DEARBORN STREET CHICAGO, ILLINOIS

THERMOCOUPLE PYROMETERS EASILY MADE

Bulletin No. D-143

-INCLUDES-

Concise, detailed instructions that enable the average practical shop man to make his own thermocouple pyrometers - - instruments used for reading temperatures as high as 2500 F., entirely above the range of thermometers. Applications are in heat-treating metals, melting metals, working with ceramics, applying baked-on enamels, recording high temperatures on motors, machines, bearings, etc. This bulletin covers all angles, telling what kind of wires to use, what sizes of wires are needed, how a millivoltmeter is selected for the purpose, how wires are fused together at the "hot junction", calibrating the instrument, etc. All of this valuable technical information has been simplified for the average layman who is unfamiliar with technical terminology.

-$1.00-

All Technical information, processes and methods recommended in this bulletin have been checked or tested and approved.

Technical Service Bureau, Inc.
By CLYDE A. CROWLEY
Technical Director

TABLE OF CONTENTS

TABLES

ILLUSTRATIONS

CHARTS

THERMOCOUPLE PYROMETERS EASILY MADE

Offering an accurate and serviceable method of measuring temperatures as high as 2500°F., thermocouple pyrometers will be found useful in the shop. They are generally used when measuring high temperatures, such as are needed for heat-treating and melting metals, working with ceramics, and applying baked-on enamels. They are also extremely useful in taking the temperatures of electric motors, machine parts, bearings, and the like, which cannot be reached with a thermometer. Often they offer the only practical means of measuring temperatures. Thermocouple pyrometers are of great value in the shop and experimental work. They are simple in design and easy to build, and anyone can learn how to make and use pyrometers by following the complete tested information given in this Bulletin.

WHAT THERMOCOUPLES CONSIST OF - A thermocouple consists of two wires of different metals, welded or brazed together at one end. If this junction is at a different temperature than the opposite end of the wires, an electrical potential of voltage is set up. The exact voltage depends on the difference in temperature. While the voltage is of very small magnitude, it can be measured by means of a millivoltmeter connected across the free ends of the wires. A millivoltmeter is simply a voltmeter capable of measuring voltages as low as 0.001 volt, or perhaps even lower. The voltage as read on this meter is a measure of the temperature at the junction. An instrument of this type used for measuring temperatures is called a thermocouple pyrometer, or simply a thermocouple.

METALS USED IN THERMOCOUPLES - In designing thermocouples, it is first of all necessary to decide on the type of metals to use for the two wires. There are a number of different combinations of wires that can be used, but for most purposes, the choice is limited to the seven pairs of metals given in Table I, which also gives the voltages for each couple at various temperatures, together with the maximum temperatures with which each can be used. For temperatures as high as 2500°F., it is necessary to use a thermocouple made up of Chromel and Alumel wires. Higher temperatures cannot be measured readily since the common thermocouple metals either melt or lose their sensitivity at such high temperatures. Only platinum and other expensive materials can stand such high temperatures. If it is not necessary to measure temperatures as high as that, one of the other standard thermocouple combinations listed in Table I can be used. A couple made from Nichrome IV or V and Advance wire, as is shown in the table, is the most sensitive combination, since it gives the highest reading for a given temperature rise. This couple can be used at temperatures up to 1600°F. Decision as to what wires to use should be made after determining various factors, such as temperature to be reached, sensitivity required, etc.

The "thermal electromotive force" or thermocouple voltages at various temperatures which can be obtained from several typical thermocouples is shown in Chart I. This chart is based on the data given in Table I. The voltage which can be obtained from any couple at any temperature can be read from the chart by subtracting the value for one metal from that of the other. This chart shows why only a few thermocouple combinations are satisfactory. The difference between Nichrome and iron, for example, is too low to permit accurate reading of the instrument. Since Advance is so low on the chart (along the base line, all other voltages on the chart being referred to it), it is easy to see why it is used in so many thermocouples.

NOTE:- Nichrome, Advance, Chromel, etc., are manufacturers' trade names for wires of special compositions. Chromel A and Tophet A are of approximately the same composition as Nichrome IV and V. Chromel C and Tophet C are about the same as Nichrome. Copel, Constantan and Cupron are approximately the same as Advance. The Chromel used in Chromel-Alumel thermocouples is Chromel P (not A or C). If other metals are substituted for the metals listed in the table, the voltages obtained may differ because of difference in composition and it will be advisable to calibrate the thermocouple according to directions given in the Bulletin.

DESIGN OF THE THERMOCOUPLE - After selecting the metals to be used, the next step is to decide on the type of installation. This should be based on the intended use of the instrument. If it is to be used for measuring the temperature of metals melting in an open crucible, the form shown in Fig. 1 will be found most useful. This consists simply of a small millivoltmeter mounted in a portable wooden handle. The ends of the thermocouple wires are attached to the binding posts of the instrument, as shown. If heavy, rigid wire is used, this arrangement will be found quite handy around the shop.

For permanent installations, where the instrument will be used to measure the temperature inside a furnace or oven, the arrangement shown in Fig. 2 will be more satisfactory. With this arrangement, the millivoltmeter is mounted at a convenient location on the wall, where it can be easily read. The wires are run to the junction, which is permanently installed in the furnace or other apparatus.

A rugged portable pyrometer is illustrated in Fig. 3. It consists of a length of gas pipe or seamless steel tubing which is welded closed at one end. The lead wires from the thermocouple to the meter must be well insulated, both from each other and also from the pipe. They may be as long as desired, provided they are heavy enough. To use a pyrometer of this type, the meter is set at any convenient point and the tube containing the thermocouple is inserted into the furnace or wherever the temperature is to be measured. A pyrometer of this type is particularly valuable in working with molten metals, since many of the metals commonly used will alloy with the thermocouple metals, and thus change the instrument reading.

ASSEMBLY - Next, the needed materials are obtained. Millivoltmeters are available from various instrument manufacturers and supply houses. For ordinary work, an inexpensive type of direct-current instrument will be perfectly satisfactory, but if extreme accuracy is desired, it is well to use a more expensive, high resistance instrument. The wires used for the thermocouple should be as large as is practical to prevent losses and to make the instrument as accurate as possible. Thermocouples for use at high temperature should be no smaller than No. 10 or 12 wire. For intermittent use at lower temperatures, provided the leads are short, No. 12, 14, or even 18 wire can be used satisfactorily.

The exact length of wire needed to reach from the thermocouple location to the meter should be measured. Many of the alloy wires used in thermocouples are difficult to cut, and the corner of a grinding wheel will be found useful for this purpose. A high-speed abrasive cut-off wheel can be used if available. The grinding wheel will also be found handy in removing oxide or corrosion from the ends of the wires so that they will make good contact with the binding posts of the millivoltmeter.

FORMING THE JUNCTION - Next, the ends of the wires are secured side by side in a vise, with the ends of the two wires protruding about an inch above the vise jaws. They are twisted together, as shown in Fig. 4, with a pair of pliers. The twist should be made regular and firm to assure good contact. If the thermocouple is to be operated at temperatures below the melting point of brazing spelter or silver solder, the junction can be brazed neatly by heating it with the torch, sprinkling with borax, and applying just enough silver solder or spelter to flow into the junction and insure good contact.

WELDING THE COUPLE - For work at higher temperatures, where brazing would not be satisfactory, the joint must be welded. The easiest way to accomplish this is shown in Fig. 5. The oxy-acetylene torch is mounted in the vise in such a way that the flame is horizontal. The gas and air valves are adjusted to produce a slightly reducing flame about 6 to 8 inches long, and with an inner cone about 1-1/4 or 1-1/2 in. long. A reducing flame is produced when a slight excess of acetylene is fed to the flame.

The twisted junction is then held in the flame until both wires become red hot. The junction is withdrawn and dipped into a good welding flux. For best results, use an intimate mixture of borax, 6 parts, and fluorspar, 1 part. If fluorspar is not available, straight borax can be used. The flux will stick to the wire, since it is melted at the high temperature. The flux-covered wire junction is then

brought back into the hottest part of the flame and kept moving to insure even heating. One of the wires will tend to melt before the other, and some care will be required to prevent it from flowing before the other wire reaches its melting point. Careful manipulation in the flame will get around this difficulty so that a sound, neat weld results. When both wires have just reached their melting temperatures, rotate the couple carefully so that the metal from both wires flows together and forms a small ball of molten metal. If the job has been handled satisfactorily, this little ball which flows to the tip of the couple will consist of an intimate mixture of both of the metals.

In welding a thermocouple by this method, it is very important to avoid overheating and consequent burning of the metal. A burned junction is mechanically weak and, in addition, it will not give accurate temperature readings when attached to the millivoltmeter.

It is important to finish the weld at the first attempt, since repeated heating and cooling of the alloy will cause certain changes which will prevent it from operating properly. If the first joint is unsatisfactory, the end should be cut off and a new junction prepared. After a little practice, it will be easy to handle the job properly.

CONNECTION TO THE METER - When the junction has been properly prepared, the other ends of the thermocouple wires are filed or ground bright and clean to insure good contact, and attached to the binding posts of the millivoltmeter. To check the instrument for polarity, that is, to make sure that the right wire is attached to each terminal, the couple can be held in the flame of a burner while you watch the needle of the instrument. If the needle tends to move in the wrong direction, it is only necessary to reverse the connections to the meter terminals. At the same time, this test offers a check on the quality of the weld. If heating in the flame produces a regular deflection of the meter, then the weld is satisfactory and you are ready to proceed with the mounting of the pyrometer.

FINAL MOUNTING DETAILS - If the portable unit shown in Fig. 1 is used, it is only necessary to bend the wires carefully so that they can be attached tightly to the binding posts of the millivoltmeter. The wires can then be formed to any convenient shape for insertion into the crucible or furnace while the millivoltmeter is held in a convenient position for reading.

If a permanent installation, as shown in Fig. 2 is decided upon, the wires will have to be insulated. If the temperature is not high enough to fuse them, glass or porcelain beads can be slipped over the wires where they are passed through the wall. Lengths of porcelain tubing can be used in the same way. There are also special pyrometer tubes, made of fused alumina, which can be used in this type of installation or where the pyrometer is encased in a metal tube. Enclosing the junction in a metal tube is a good idea to afford additional protection at the high temperatures in the furnace. Pyrometer tubes, made of fused alumina and closed at one end, are also made for this purpose. They will stand any temperature up to about 2500°F. without damage.

For a portable pyrometer with the thermocouple inside a metal tube, the best method of insulation is to use regular thermocouple tubing. This is made of fused alumina as mentioned in the previous paragraph. It is available in two types, single-bored or double-bored - i.e., for one or two wires in the same tube. In making a pyrometer of this type, it is a good idea to consider the couple in selecting the metal tube. For example, neither Chromel nor Alumel contains an appreciable amount of iron. The best practice, then, would be to use nickel or Nichrome tubing to enclose the couple. However, iron can be used without serious damage if the temperature does not get excessively high.

CALIBRATING THE PYROMETER - In Fig. 6 is shown a millivoltmeter scale to which has been added figures giving corresponding temperatures for use with a Nichrome-Advance thermocouple. Similar scales can be drawn for pyrometers made with other combinations of metals. Simply mark the meter scale with the temperatures corresponding to various voltages, as given in Table I. To use the pyrometer, adjust the zero regulating screw of the meter so that the needle points to the proper voltage when the junction is at room temperature. If you do not want to remove the face from the millivoltmeter and thus take a chance of impairing the accuracy of the instrument, a satisfactory method is to prepare a chart similar to Chart I, which gives the temperatures corresponding to milli-

voltmeter readings. A chart of this type can be placed on the wall, close to the meter for quick reference.

A better way of calibrating the instrument is to determine directly the millivoltmeter readings at various temperatures. The customary method is to immerse the junction in various molten metals in order to determine the voltages at their solidification points. (This is more accurate than finding the melting point.) Table II gives the solidification or freezing points of several pure metals which can be used for this purpose. As the metal cools slowly, watch the millivoltmeter. The reading will fall gradually until the freezing point is reached, at which time it will hold steady for a short time before continuing its drop. The constant reading before the needle starts to drop again is the freezing point of the metal. To check the determination, another reading is made in the same way, and the average is taken as the freezing point. The best procedure then is to mark the temperatures and voltages determined on graph paper, which can be purchased from any stationery store, and draw straight lines to represent the calibration curve. These values can be transferred to the face of the meter if desired. A calibration curve drawn in this way is shown in Chart II.

MORE ACCURATE READINGS - The readings given by a thermocouple connected in the way previously described are slightly in error for two reasons. First, the temperature of the "cold junction", which in this case is at the meter, is subject to fluctuations which will affect the reading slightly. Second, there is a loss in voltage due to the current which passes through the wire. Neither of these effects is of large magnitude, and for most practical purposes they can be neglected. If large wires and a high-resistance millivoltmeter are used, the latter effect can be neglected entirely, except in scientific work where the greatest possible accuracy is essential. However, sometimes the temperature rise or room temperature change may be important; for example, in the case of a pyrometer mounted close to a furnace, where there may be an appreciable change in temperature at different times. If freedom from the effect of temperature changes is desired, a circuit such as is shown in Fig. 7 can be used. The junction which is at the temperature of the substance being measured, is generally called the "hot junction". Another junction is called the "cold junction", and should be kept at a constant temperature. An efficient way of doing this is to place the cold junction in a vacuum bottle with melting ice in distilled water, which will maintain it at a temperature of 32°F.

NOBLE METAL THERMOCOUPLES - The principal advantage of thermocouples made from precious or "noble" metals such as platinum is that they are not subject to corrosion and that they can be used at higher temperatures than any other thermocouples. For example, a platinum - platinum 87% and rhodium 13% - thermocouple can be used at 2800°F. continuously, and up to 3000°F. for intermittent service. The disadvantage of the high cost of these metals is so tremendous that they are not often used where other metals will serve the purpose. When it is necessary to use a noble metal thermocouple because of high temperature, the junction is formed just as with base metal couples except that no flux is used in welding. The joint should not be brazed. Millivoltmeter readings for various temperatures with these couples are given in Table III. Because of their cost, noble metal thermocouples generally consist of small wires.

SUPPLY DIRECTORY

THERMOCOUPLE WIRES: Nichrome, Nichrome IV and V, Advance, Nickel and Chromel-Alumel:

Technical Service Bureau, Inc.
407 South Dearborn Street
Chicago, Illinois

THERMOCOUPLE TUBING (Fused Alumina):

The Norton Company
Worcester, Mass.

MILLIVOLTMETERS:

Readrite Instrument Works
Bluffton, Ohio

Reliance Instrument Company
1135 Van Buren St., Chicago, Ill.

PLATINUM AND PLATINUM ALLOY WIRES:

Baker & Company, Inc.
55 E. Washington, Chicago, Ill.

TABLE I

THERMOCOUPLE DATA

Metals Used	Chromel Alumel	Nichrome IV Nickel	Nichrome Nickel	Nichrome Advance	Nichrome IV Advance	Iron Adv.	Copper Adv.
Temp. Deg. F.	MILLIVOLTMETER READING						
2500°	54.85						
2400	52.95						
2300	51.00						
2200	49.01						
2100	46.97	48.72					
2000°	44.89	46.40					
1900	42.77	44.08					
1800	40.62	41.76	29.52				
1700	38.43	39.44	27.88				
1600	36.20	37.12	26.24	54.40	65.44	47.52	
1500°	33.94	34.80	24.60	51.00	61.35	44.55	
1400	31.65	32.48	22.96	47.60	57.26	41.58	
1300	29.33	30.16	21.32	44.20	53.17	38.61	
1200	26.98	27.84	19.68	40.80	49.08	35.64	
1100	24.62	25.52	18.04	37.40	44.99	32.67	
1000°	22.25	23.20	16.40	34.00	40.90	29.70	
900	19.88	20.88	14.76	30.60	36.81	26.73	
800	17.52	18.56	13.12	27.20	32.72	23.76	
700	15.18	16.24	11.48	23.80	28.63	20.79	
600	12.85	13.92	9.84	20.40	24.54	17.82	13.38
500°	10.56	11.60	8.20	17.00	20.45	14.85	11.15
400	8.31	9.28	6.56	13.60	16.36	11.88	8.92
300	6.09	6.96	4.92	10.20	12.27	8.91	6.69
200	3.82	4.64	3.28	6.80	8.18	5.94	4.43
100	1.52	2.32	1.64	3.40	4.09	2.97	2.23
Meter Range	0-60	0-50	0-30	0-60	0-70	0-50	0-15

TABLE II

SCLIDIFICATION POINTS OF METALS

Metal	Freezing Point
Tin	449°F.
Lead	621
Zinc	787
Aluminum	1220

TABLE III

NOBLE METAL THERMOCOUPLES

Temperature Deg. F.	Platinum vs. Alloy of Platinum 90% with Rhodium 10%	Platinum vs. Alloy of Platinum 87% with Rhodium 13%	Temperature Deg. F.	Platinum vs. Alloy of Platinum 90% with Rhodium 10%	Platinum vs. Alloy of Platinum 87% with Rhodium 13%
32	0.00	0.00	1600	8.11	8.89
100	0.22	0.30	1700	8.73	9.61
200	0.59	0.62	1800	9.37	10.35
300	1.01	1.06	1900	10.01	11.10
400	1.47	1.53	2000	10.66	11.86
500	1.95	2.03	2100	11.32	12.64
600	2.46	2.64	2200	11.98	13.44
700	2.97	3.09	2300	12.65	14.25
800	3.50	3.68	2400	13.32	15.07
900	4.04	4.27	2500	13.98	16.23
1000	4.59	4.90	2600	14.66	16.78
1100	5.15	5.53	2700	15.34	17.65
1200	5.73	6.17	2800	16.00	18.54
1300	6.31	6.82	2900	16.67	19.44
1400	6.89	7.49	3000	17.34	20.35
1500	7.50	8.19			

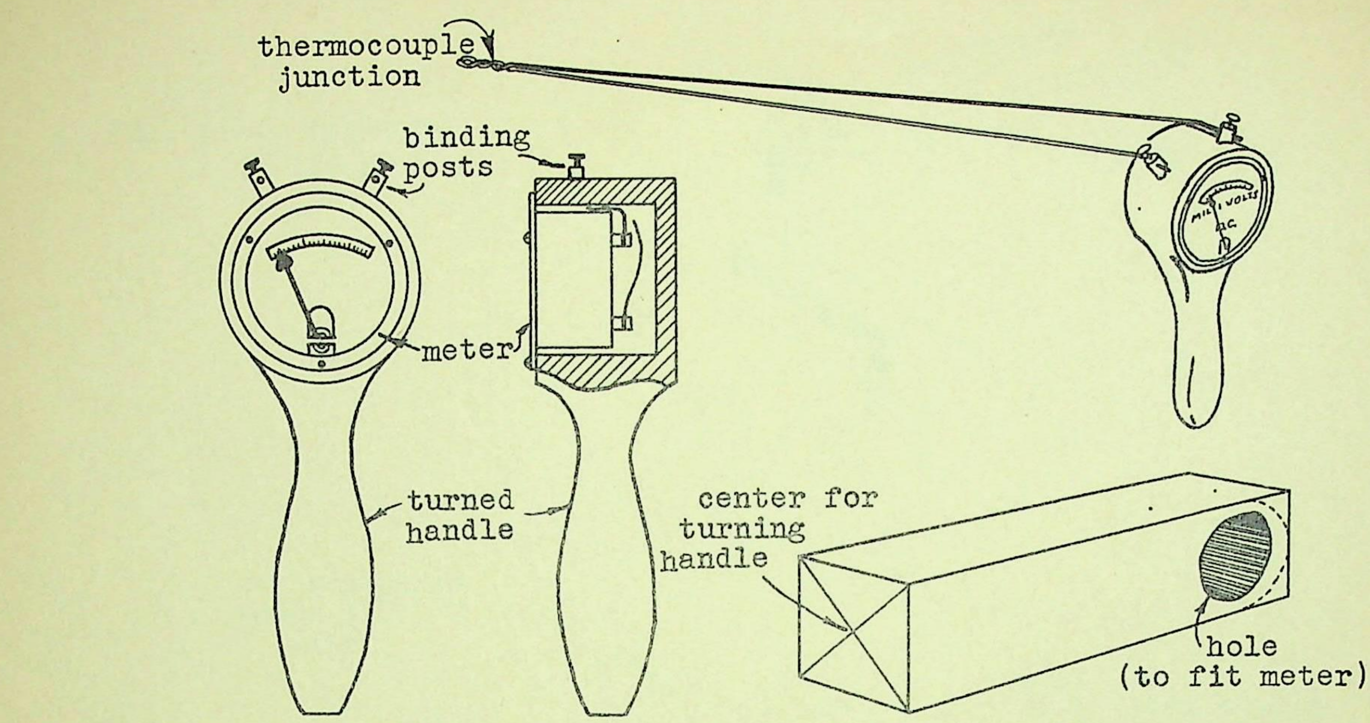


FIG. 1 --- PORTABLE THERMOCOUPLE

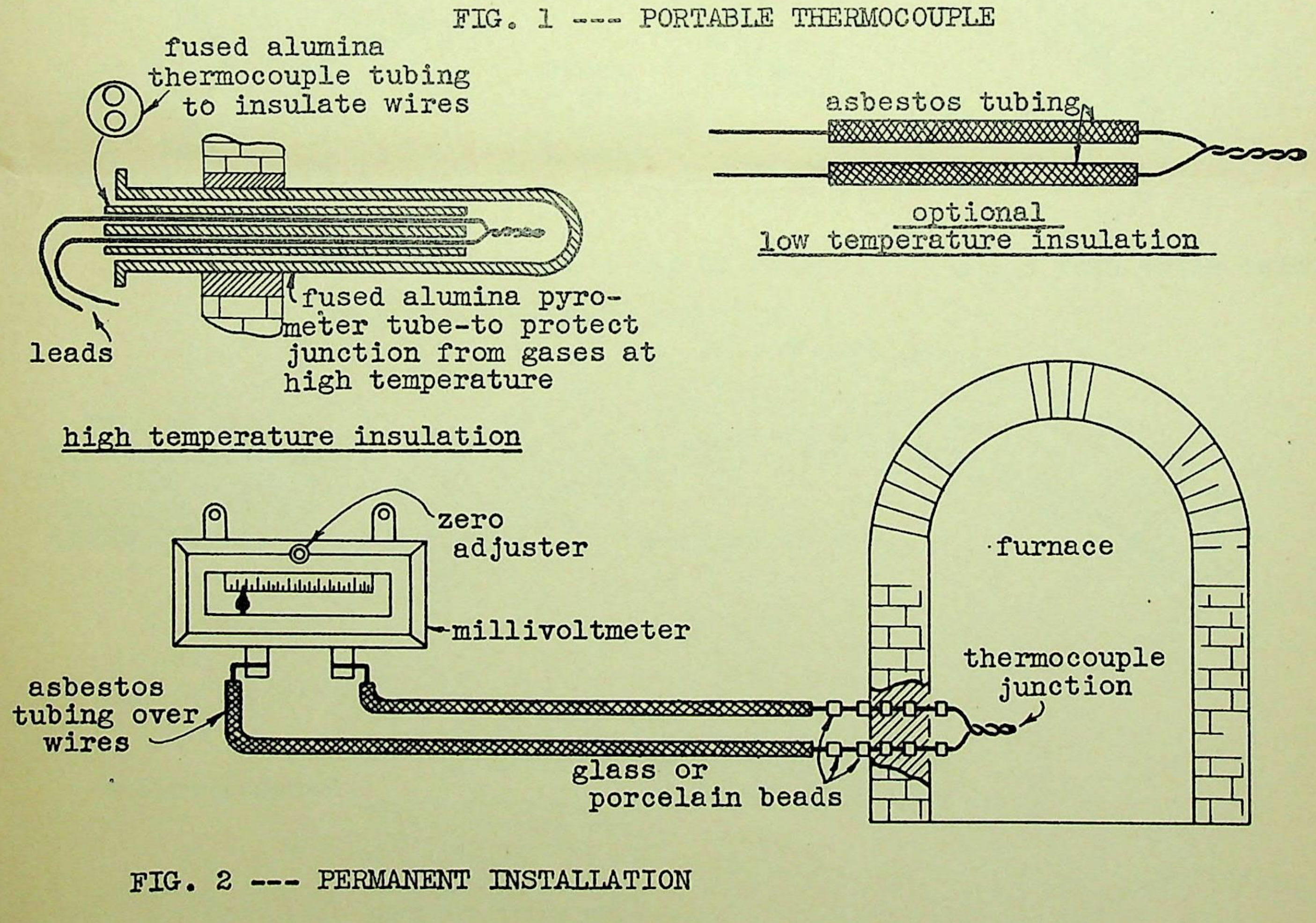


FIG. 2 --- PERMANENT INSTALLATION

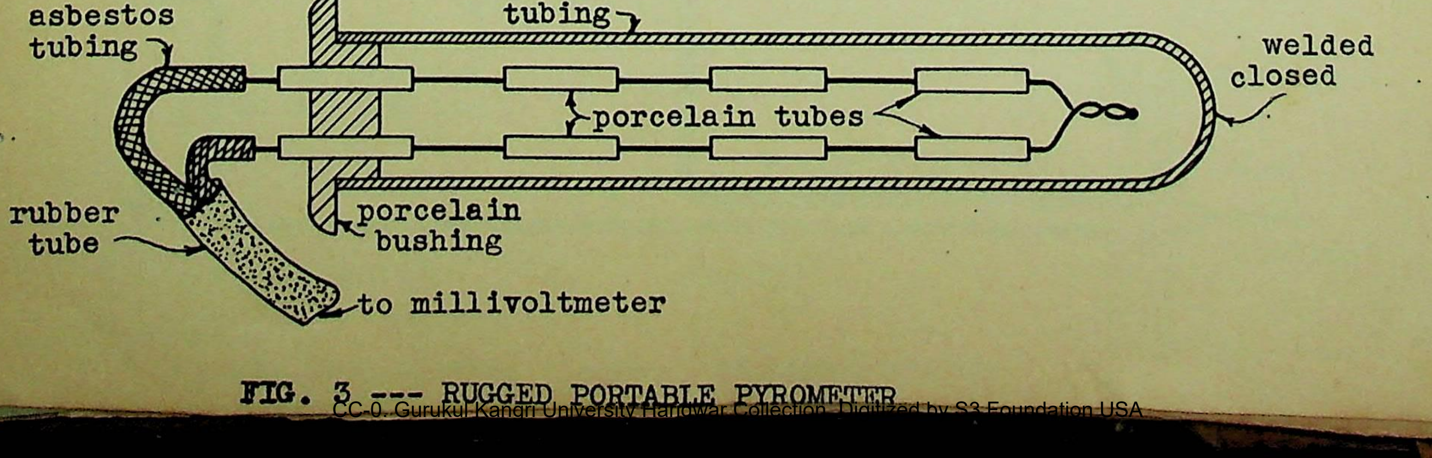
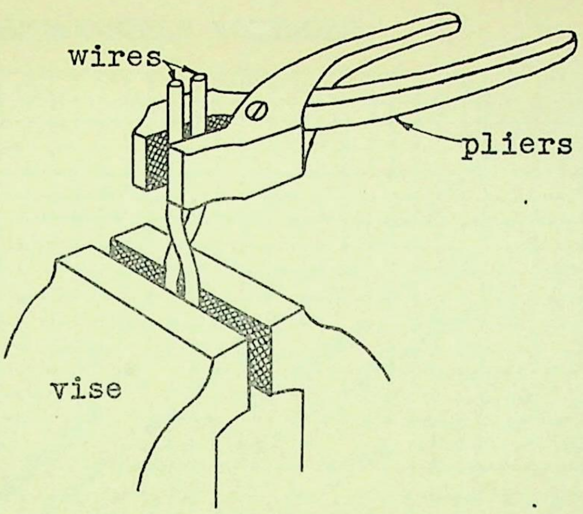


FIG. 3 --- RUGGED PORTABLE PYROMETER

FIG. 4 --- TWISTING WIRES



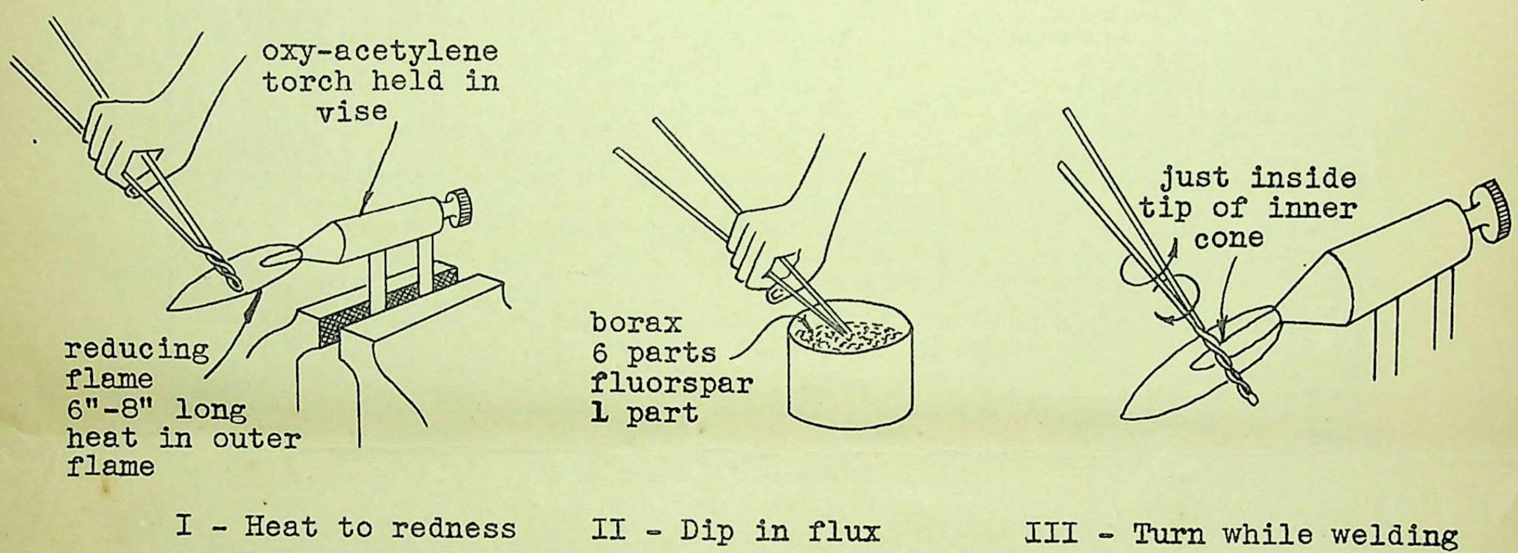
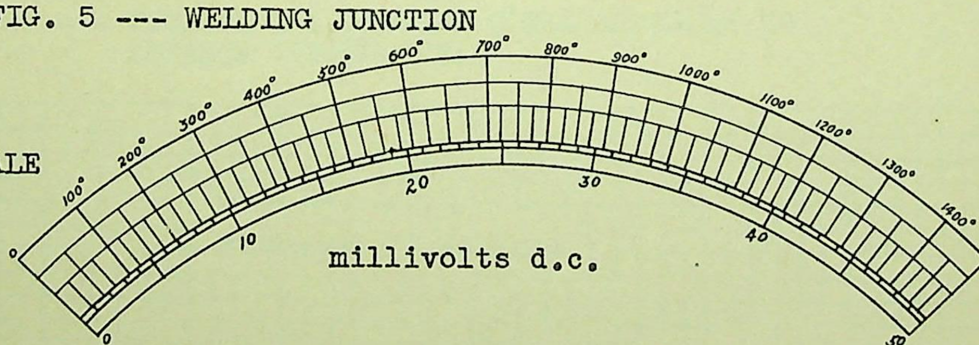


FIG. 5 --- WELDING JUNCTION

FIG. 6 --- MILLIVOLTMETER SCALE WITH TEMPERATURES (NICHROME ADVANCE THERMOCOUPLE)



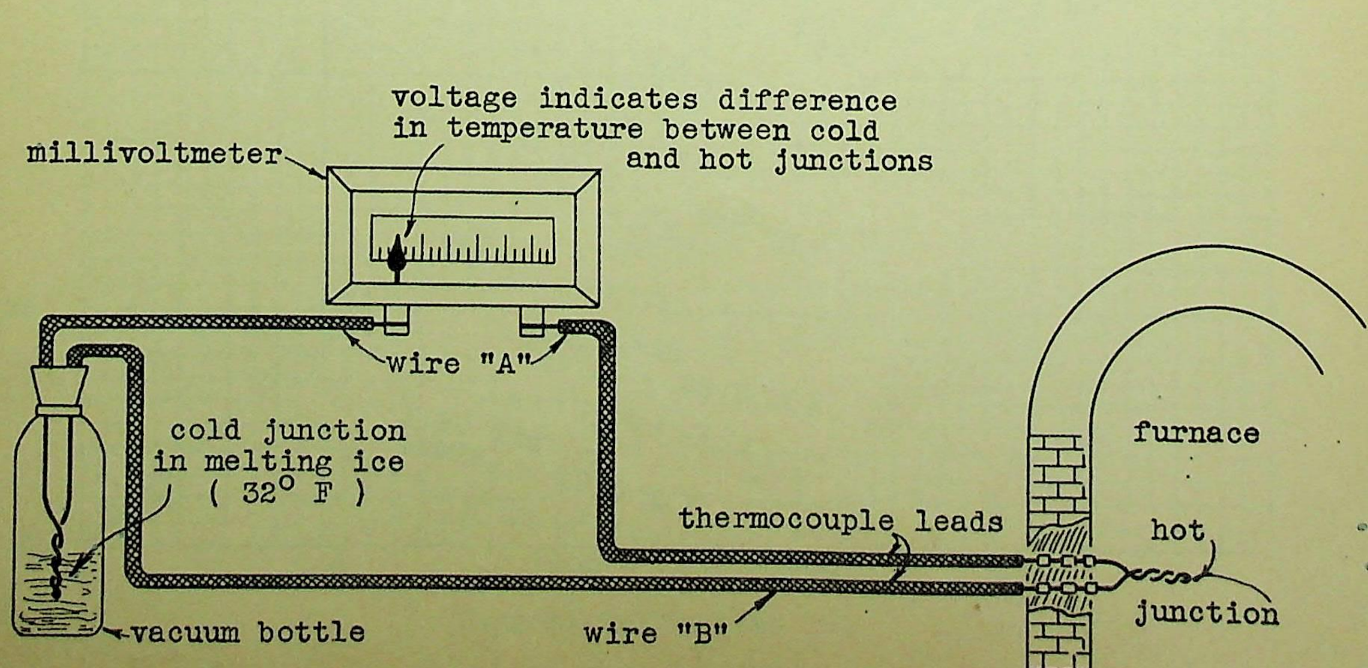


FIG. 7 --- MORE ACCURATE PYROMETER CIRCUIT

CHART 1. --- THERMOCOUPLE VOLTAGES

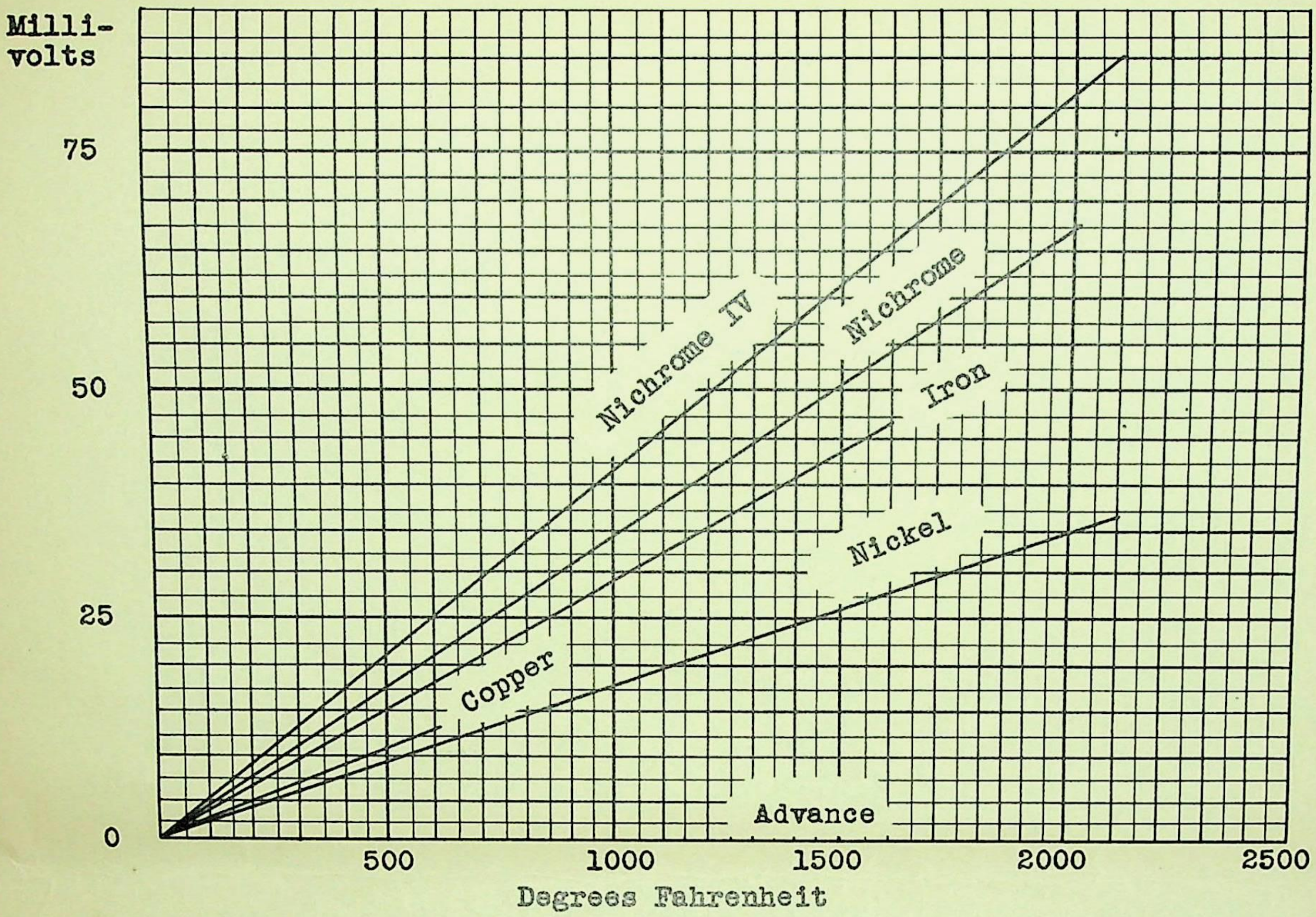
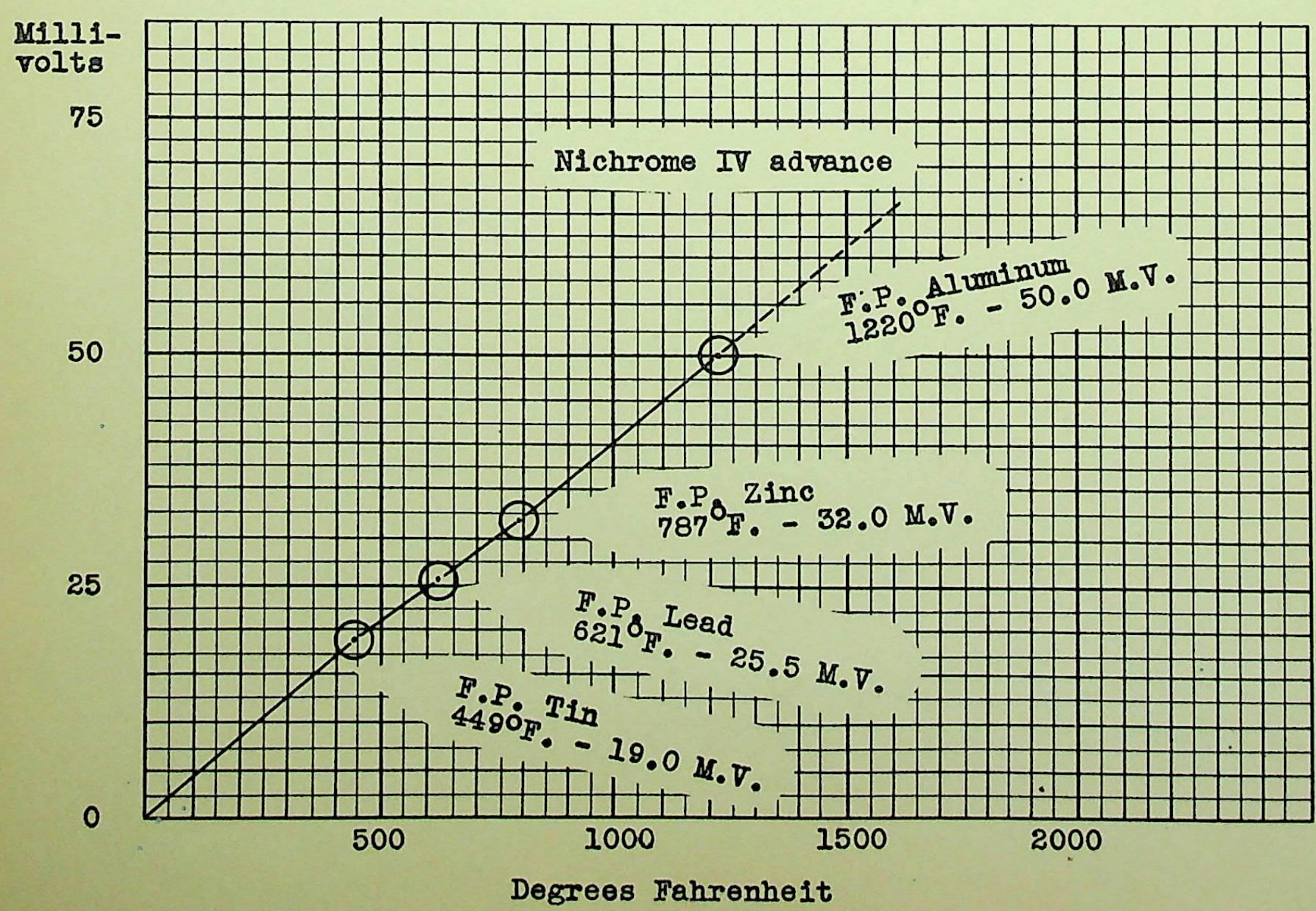


CHART 2. --- TYPICAL CALIBRATION CURVE;NICHROME IV
ADVANCE THERMOCOUPLE



TECHNICAL BULLETIN

FROM

Technical Service Bureau, Inc.

CHEMISTS · ENGINEERS · INSPECTORS

407 S. DEARBORN STREET CHICAGO, ILLINOIS

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27022

AUTOMOBILE SPECIALTY CHEMICAL PRODUCTS

Bulletin No. D-103

Formulas and complete instructions for making the following and other products used by automobile owners: Penetrating oil, Spring spray, Chromium and Nickel polish, Radiator and Cooling System cleaner, Anti-dimming paste for Windshields, Protective battery terminal coating, Corrosion preventatives, Auto finish cleaner, Easy rubbing wax polish, Road tar solvent, Polishing cloth, Rain repellent, Radiator corrosion inhibitor, Oil type glossy polish and others of equal practical utility.

-$1.00-

All Technical information, processes and methods recommended in this bulletin have been checked or tested and approved.

Technical Service Bureau, Inc.
By CLYDE A. CROWLEY
Technical Director

TABLE OF CONTENTS

FORMULAE FOR THE MANUFACTURE OF AUTOMOBILE SPECIALTY PRODUCTS

These formulae describe methods for making a number of products which are used in maintaining, servicing, and caring for the automobile. Each formula is for a special purpose.

At the end of this bulletin will be found a list of Chemical Manufacturers and Distributors who can supply the various chemicals required.

In each of the formulae a Roman numeral has been placed before the name of each chemical ingredient. To find the manufacturer or distributor, simply locate this number on the list at the end of the Bulletin.

CLEAR VISION COMPOUND FOR WINDSHIELDS
(Formula D-103 - I)

(III)	Tallow (fresh)	3	lbs.
(III)	Cocoanut Oil	1-1/2	lbs.
(III)	Caustic Soda (40° Be. solution)	2-1/2	pints
(VI)	Alchohol (denatured)	2	pints
	Brown sugar	1	lb.

METHOD OF MANUFACTURE:

1) Melt the tallow and cocoanut oil together at 167° F.
2) Mix the last three ingredients thoroughly and heat to 167°F.
3) Run the molten tallow oil mix into the last solution slowly while stirring (both at 167°F.)
4) Cover and when cooled to 95°F. add Oil of Bergamot or other perfume oil as desired.
5) While still liquid, the mass should be poured into shallow pans and cut into sticks of the desired size and shape for use.

NOTE: Rubbing these sticks over glass will prevent clouding for a considerable time. This product may be converted into a paste of consistency suitable for dispensing in collapsible tubes by adding hot water in suitable proportions to the molten mass.

RAIN REPELLENT
(Formula D-103 - II)

(IV)	Glycol Bori-Borate	2 oz.
(III)	Glycerine	5 oz.

METHOD OF MANUFACTURE:

Dissolve the Glycol Bori-Borate in the Glycerine with gentle heat and stirring. The product is best sold in small bottles.

USE: Apply the product to the outside of the glass with a small piece of cloth. When driving in a mist or rain, the windshield wiper should be released to make a single stroke from time to time, but need not be operated continuously. This repellent will keep the glass remarkably clear and free from reflections caused by water droplets.

ANTI-DIMMING PASTE FOR WINDSHIELDS
(Formula D-103 - III)

(I)	Diethylene Glycol	1-1/2	oz.
(III)	Chalk (precipitated)	1	oz.

METHOD OF MANUFACTURE:
Mix the ingredients thoroughly. More or less chalk may be added to give any desired consistency. The product may be packed in jars or collapsible tubes.

USE: This product is applied to the glass with a rag and rubbed until a polish is produced. This item is useful for preventing sweat and frost on the inside of windows. For a rain repellent, see D-103 - II.

RADIATOR AND COOLING SYSTEM CLEANER
(Formula D-103 - IV)

Rust, corrosion and foreign matter can be removed from the radiator and cooling system of automobiles with a solution made by dissolving sodium bisulphate, 14 oz., in enough water to almost fill the radiator.

USING THE PRODUCT: The radiator must be drained and flushed with water if it has contained alcohol or other anti-freeze solution. The sodium bisulphate solution is then poured in and the motor allowed to run until the solution is hot. The motor is then run for from one to two hours, after which the solution is drained, the radiator again flushed and refilled with water or anti-freeze solution. The owner of the car may drive for the time required for the cleaner to work, provided he drains and flushes out the chemicals within two hours.

NOTE: Old cars whose radiators may have been doped with sto-leak preparations or which leak slowly should not be treated by this process as the removal of rust, corrosion and stop-leak dope will result in leaks. This material is harmless to sound radiators when used according to directions.

RADIATOR CLEANER AND CORROSION INHIBITOR
(Formula D-103 -V)

(V)	Alox 800 Compound	1 lb.
(VII)	Pyradine Deodorant #05416	As required
VI)	Ammonia Gas	As required
	Water	3 pints

METHOD OF MANUFACTURE:
The ingredients are mixed together and ammonia gas (from a cylinder) is bubbled in until the odor of ammonia is given off by the solution. This treatment converts the Alox 800 Compound into an ammonium compound. The resultant product contains no free acid and apparently does not attack rubber.

If ammonia gas is not available, 28% ammonium hydroxide solution may be added to the Alox 800 compound (no water added) until entirely dissolved and the solution has a slight ammoniacal odor. This addition should be made while stirring to insure complete reaction. After adding all of the ammonium hydroxide required, enough water should be added to bring the water content up to three times that of the Alox 800 compound used. (Ammonium hydroxide of the strength indicated above contains 72% by weight of water.) After the product has been completed by either of the above methods, it should be allowed to stand overnight, and skimmed on the following day if any material has come to the top.

NOTE: This product is used by adding a half pint of it to the radiator. It should be left in the radiator for permanent protection. In using this product, it should be borne in mind that the material will bring about the loosen-

ing of rust which has formed inside the cooling system. After placing the product in the radiator the first time and running for the equivalent of 15 or 20 hours, it is advisable to drain the radiator and completely flush to remove the loosened rust. The radiator should then be refilled with clean water and another portion of the cleaner added. The second batch of cleaner will tend to inhibit the formation of further corrosion. The pyradine deodorant is added as required if it is desired to cover the odor of the Alox 800 Compound.

TAR SOLVENT
(Formula D-103 - VI)

Ethylene Dichloride is an excellent solvent for the road tar which accumulates on the fenders of automobiles when driven over newly oiled roads. This solvent should be used straight, or it may be mixed with an equal amount of (II) Naphtha to cut the cost without serious loss of solvent properties.

EFFICIENT PAINT AND TAR SOLVENT
Formula D-103 - VII)

(III)	Ethylene Dichloride	6 pints
(III)	Trichlorethylene	4-1/2 pints
(III)	Xylene	1-3/4 gals.
(V)	Alox 400 Compound	3/4 gal.
(VI)	Isopropyl Alcohol	3-1/4 pints
(III)	Sulphonated Castor Oil	2-1/2 pints
(VI)	Triethanolamine	1-1/2 lb.

METHOD OF MANUFACTURE:

(1) Mix the ethylene dichloride with the Alox 400 Compound and add the triethanolamine while stirring.

(2) Add to the above the trichlorethylene, xylene, isopropyl alcohol and sulphonated castor oil and stir thoroughly.

NOTE: This composite solution rapidly dissolves many types of paint, tar, etc., which resist ordinary removers.

REMOVING GREASE SPOTS FROM UPHOLSTERY
(Formula D-103 - VIII)

Grease spots on upholstery may be removed by rubbing with (VI) calcined magnesia rubbed into a paste with (VI) benzene. The benzene is the solvent for the grease and the magnesia absorbs it rapidly. For old grease spots it may be necessary to apply the preparation several times. The paste is rubbed in with the fingers.

AUTO FINISH CLEANER
(Formula D-103 - IX)

(IV)	Blendene	12 oz.
(II)	Kerosene	2-1/2 pints
	Water	6-1/4 pints
(I)	Infusorial Earth	1-1/2 lbs.

METHOD OF MANUFACTURE:

1) Dissolve the Blendene in the kerosene by mixing.
2) Run the water into the kerosene solution while mixing at high speed. Mixing should be continued until the batch is smooth and creamy.
3) Add the infusorial earth to the product and stir in well.

USE: This product may be packaged in cans, which should be shaken before use. To clean the finish, apply with a soft cloth and rub to loosen all dirt. The finish may then be easily wiped clean and bright with a wiping cloth. Finishes cleaned with this product can be waterproofed with the polish described in the next formula, or left clean and lustrous without further treatment.

HIGH GLOSS EASY RUBBING WAX POLISH
(Formula D-103 - X)

(I)	Carnauba Wax (No. 1 refined)	1-1/4 lbs.
(III)	Castile Soap or high grade laundry soap	5 oz.
(III)	Oleic Acid (red oil)	1 oz.
(III)	Sodium Hydroxide (sticks)	1/2 oz.
	Water	1-1/2 gal.

METHOD OF MANUFACTURE:

1) Heat the carnauba wax and the oleic acid together until melted (210°F.), while stirring vigorously.
2) Dissolve the castile soap and then the sodium hydroxide in the water and heat to 180°F.
3) While stirring rapidly, run the hot water solution into the first solution (while molten). Mixing should be continued until the polish is of even creamy consistency.

NOTE: This product may be colored by adding Nigrosine dye (black oil soluble) to the wax mixture after melting, but before adding the water. Other oil soluble aniline dyes may be used for other colors.

USE: This high luster, easily polishing product is applied to the cleaned surface with a soft cloth and polished with a clean cloth.

OIL TYPE GLOSSY AUTOMOBILE POLISH
(Formula D-103 - XI)

(II)	Paraffine Oil	20 fl. oz.
(VI)	Linseed Oil, raw	8 fl. oz.
(VI)	China Wood Oil	2 fl. oz.
(III)	Benzol	1 fl. oz.
(II)	Kerosene	1 fl. oz.

METHOD OF MANUFACTURE:
Mix the benzol and kerosene and add the oils and mix thoroughly.

NOTE: The polish should be applied sparingly with a soft dry cloth. Cleaning before polishing is as usual a matter of necessity.

POLISHING CLOTH
(Formula D-103 - XII)

(III)	Oleic Acid	12 oz.
(I)	Stearic Acid (double pressed)	6 oz.
(II)	Petrolatum	4 oz.
(I)	Methyl Salicylate	1/2 oz.

METHOD OF MANUFACTURE:

1) Melt together the oleic acid, stearic acid and petrolatum, and add the methyl salicylate while stirring.
2) Pieces of canton flannel, one-half yard square, are

soaked in the molten oils and run through a tight wringer.

3) The finished cloths are packed in cellophane envelopes.

USES: These polishing cloths are unexcelled for quickly and easily removing dust and restoring luster to automobile finishes.

CHROMIUM AND NICKEL POLISH
(Formula D-103 - XIII)

(I)	Tripoli	1-1/4 lbs.
(I)	Pine Oil (steam distilled)	1-1/2 pints
(III)	Oleic Acid	7 fl. oz.
(III)	Sodium Hydroxide, sticks	1/2 oz.
	Water	3 pints

METHOD OF MANUFACTURE:

1) Mix the pine oil and the oleic acid.
2) Dissolve the sodium hydroxide in the water and run this solution into the oil while mixing. Mixing should be continued for about five minutes.
3) The tripoli is finally added and thoroughly mixed in.

USE; This metal polish is applied with a soft cloth.

CORROSION INHIBITING METAL POLISH
(Formula D-103 - XIV)

(III)	Bentonite	2.2	lbs.
	Water	6.0	gals.
(V)	Alox 400 Compound	2.0	gals.
(VI)	Ammonia Water (sp. gr. 0.90)	0.6	gal.
(VI)	Silica (fine)	15-1/2	lbs.
(VIII)	Pyradine Deodorant (05416)	0.1	lb.
(VII)	Methylate C	0.3	lb.

METHOD OF MANUFACTURE:

1) Float the bentonite on the water and allow to stand at least 24 hours. Mix until uniform.
2) In a separate container, add the ammonia water to the Alox 400 compound and mix.
3) Add 2 to 1 while vigorously stirring. Be careful that the stirrer does not beat air into the mix. Add the silica, pyradine deodorant #05416 and the methylate C to the emulsion and stir until uniform.

NOTE: This product rapidly removes oxides and protects the clean surface from corrosion for longer periods of time than ordinary polishes.

SPRING SPRAY AND PENETRATING OIL
(Formula D-103 - XV)

(V)	Alox 300 compound	1 lb.
(VIII)	Halowax 1014	1 lb.
(II)	Paraffine Oil (70 sec/100°F.)	5 pints
(II)	Kerosene	45 pints

METHODS OF MANUFACTURE:

The first three items are compounded together by heating and dispensed as a concentrate from which the finished product can be produced by diluting with kerosene or distillate.

NOTE: This product penetrates rapidly and lubricates springs well. As a penetrating oil, it may be used to loosen rusty parts, etc. It works rapidly.

NON-CORROSIVE THREAD GREASE
(Formula D-103 - XVI)

(V)	Alox 700 compound	3 lbs.
(II)	Kerosene (heavy)	6 pints
(VI)	Caustic Soda (36° Be. solution in water)	1 lb.

METHOD OF MANUFACTURE:
Dissolve the Alox 700 compound in the kerosene with the aid of heat (inflammable), and add the caustic soda solution which has been previously heated to about the same temperature. Stir vigorously until the mass is homogeneous.

NOTE: This lubricant is applied to threads during assembly.

PREVENTING BATTERY CABLE CORROSION
(Formula D-103 - XVII)

Storage battery cables as used on automobiles are quite rapidly corroded and impaired in their efficiency by battery acid. This corrosive attack may be inhibited or retarded to an extent sufficient to materially elongate their service by lubricating the cable strands with (VI) Alox 702 Compound during manufacture. This is easily applied from solvent solution by wiping, dipping, or spraying. (II) Stoddards Solvent, (II) light paraffine oil, or (II) kerosene may be used as the solvent.

PENETRATING OIL
(Formula D-103 - XVIII)

(I)	Secondary Butyl Alcohol	15 fl. oz.
(II)	Mineral Oil, light	4 pints
(II)	Kerosene	30 fl. oz.

METHOD OF MANUFACTURE:
Mix the ingredients thoroughly.

USE: This makes an excellent penetrating oil for loosening rusted or corroded screws, nuts, and other parts. The oil is dropped or sprayed on and allowed to stand for a few minutes.

BATTERY TERMINAL COATING
(Formula D-103 - XIX)

(IV)	Diglycol Stearate	12 oz.
	Water	15 pints

METHOD OF MANUFACTURE:
1) Heat the ingredients together until the Diglycol Stearate has completely melted.
2) While molten, mix at high speed (off the fire) until the batch has cooled to approximately room temperature.

USE: This product may be packed in tubes or cans. It is applied to the cleaned battery terminals. After drying, the synthetic wax coating will prevent battery acid from coming in contact with the terminals and thus eliminate corrosion. This product is cheap to make and effective.

RUST INHIBITOR FOR PROTECTING INSIDE OF MOTOR UNITS DURING STORAGE
(Formula D-103 - XX)

(V)	Alox 701 compound	2	lbs.
(II)	Solvent	8	lbs.
	Solvent Mixture		
(II)	Gasoline (lead free)	8	pints
(VI)	Butyl Alcohol	1-1/2	pints
(VI)	Triethanolamine	1/2	pint

METHOD OF MANUFACTURE:

1) The Alox 701 Compound is dissolved in the specified amount of solvent made as follows:
2) The gasoline and butyl alcohol are mixed and the triethanolamine is added.

NOTE: This inhibitor is applied by spraying or by other convenient means. It should be completely removed by washing out with gasoline before the unit is replaced in service.

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MANUFACTURERS AND DISTRIBUTORS OF CHEMICALS

I. Chas. H. Lewis & Co.,Inc. 232 Canal St., New York, N.Y.
II. Any oil company.
III. Clarence Morgan, Inc., 919 N. Michigan Ave., Chicago, Ill.
IV. Glyco Products Co., Inc. 26 Court Street, Brooklyn, N.Y.
V. Alox Corp., Buffalo Ave., & Iroquois St., Niagara Falls, N.Y.
VI. A. Daigger & Co., 159 W. Kinzie St., Chicago, Ill.
VII. Fritzsche Bros., 76 - 9th Ave. at 15th St., New York, N.Y.
VIII. Halowax Corporation, 247 Park Avenue, New York, N.Y.

SMALL QUANTITY CHEMICAL ORDERS

The following companies carry a stock of small packages of almost any chemical item which may be needed. When purchasing small quantities, it frequently saves time to ask one of these companies to quote you a price on all items needed. Also, your local druggest can procure small quantities of most of the items.

W. M. Welch Mfg. Company, 1515 N. Sedgwick Street, Chicago, Ill.
Lewis Chemicals, Inc., 232 Canal Street, New York, N. Y.

OTHER SUPPLIES

BOTTLES & CAPS -- Berman Bros., 1806 S. Canal Street, Chicago, Ill.

BOXES, CARTONS AND LABELS -- H. S. McCracken Box & Label Company, 2640 Shields Avenue, Chicago, Illinois.

CORKS -- Armstrong Cork Company, 14 E. Jackson Blvd., Chicago, Ill.

CANS -- American Can Company, 104 S. Michigan Avenue, Chicago, Illinois.